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CORRECTIONS

Volume 63, April 1940: Page 96, column 2, 7th line from bottom, insert "fit" after "best"; page 108, column 2, line 1, for *after* read *before*; page 116, column 2, par. 2, 1st line, change *May* to *April*.

MONTHLY WEATHER REVIEW

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NIGHT RADIATION AND UNUSUAL MINIMUM TEMPERATURES NEAR NEW ORLEANS, LA.

By W. F. MCDONALD

[U. S. Weather Bureau, New Orleans, La., April 1939]

On the morning of November 30, 1938, after a clear calm night attending a center of moderately high pressure over the middle Gulf coast, a minimum temperature of 43° F. was recorded, 76 feet above ground, at the New Orleans Weather Bureau office. On the same morning at Belle Chasse substation, 5¼ miles southeast of the Weather Bureau office, the minimum temperature at 5 feet was 18°, a difference of 25° between the two stations. The difference on the preceding morning was 24°, with 40° at the Weather Bureau and 16° at Belle Chasse.

The Belle Chasse weather station was established in the summer of 1935 in connection with an intensive experiment in artificial heating for protection of citrus and high-value winter vegetable crops. Fourteen authentic cases in less than 4 years since the beginning of these records show minimum temperatures at Belle Chasse 20° or more below those recorded on the same dates at the Weather Bureau office. The difference in sea-level elevation is about 80 feet. Records are obtained from standard Weather Bureau instruments, with three sets of maximum and minimum thermometers and two thermographs in use at Belle Chasse in standard Weather Bureau shelters.

The area in which this station is located lies within a huge loop of the Mississippi River, about 7 miles long and of similar breadth. The main river levees surround the tract on three sides; the fourth is bounded by a drainage levee. Land slopes are very slight. The point of observation is near the middle of the area and the ground there is approximately 1 foot above sea level with a slight slope upward toward the river, where elevations are somewhat more than 10 feet in places, but the top of the main levee line is about 25 feet above sea level. The drainage levee crossing the open side of the river bend is lower, its top being about 12 feet above sea level.

The soil throughout the tract consists of the usual heavy black delta silt, known locally as "gumbo." No great fraction of the area is under cultivation; much of it is covered by dense thicket or forest but the whole area is artificially drained. The flat basin enclosed by levees is undoubtedly an ideal place within which to collect a shallow pool of cold air as the result of loss of heat by radiation when very still, clear night conditions prevail.

The extraordinary difference of 25° between minima in the two exposures separated by less than 6 miles of horizontal distance, and only 80 feet in sea-level elevation, is (so far as the present writer can discover in the available literature) unparalleled in meteorological records. The case therefore deserves a full report and discussion which it is the purpose of this paper to present. Records of several other ground-level stations in the flat, densely overgrown Mississippi delta will be added, for the light they throw on the factors operating to produce the conditions described.

Before proceeding to more detailed discussion of the Belle Chasse temperature records, it may be well to survey briefly some reports of other investigations in the same field.

Cox (2) studied records from the cranberry bogs of Wisconsin and found extreme differences of 14° to 16° in the minimum temperatures observed at stations separated by only about 700 feet. Careful examination of his data shows, however, that the higher of these temperatures occurred within a standard shelter 5 feet above sandy upland, while the lower readings were obtained from an unshielded minimum thermometer exposed a very short distance above moss in the bog.

Lack of shielding introduces into those records from 3° to 8° of incompatibility and the reported differences in temperatures must be reduced accordingly. Furthermore, it has more than once been shown (6, 7) that a sharp inversion of temperature amounting to as much as 6° to 8° often exists within 5 feet of the ground surface under active night radiation. This effect is much more strongly represented in the cranberry-bog records cited by Cox than in the Belle Chasse records under discussion inasmuch as the lower bog station was in the air layer within which this ground surface inversion exists whereas Belle Chasse observations are made at about 5 feet elevation and thus avoid most of the effect of the low surface inversion.

In another paper (3) Cox discusses thermal belts in the Carolina highlands and he there reports a maximum difference in night temperatures amounting to 31° F., but the stations under comparison differed by 1,000 feet in elevation. Air drainage rather than simple cooling by radiation enters strongly into these highland situations, but this factor must be almost completely absent from Louisiana delta conditions due to the lack of topographic relief.

Young (8) reports a variation of 28° in adjacent records of minimum temperature at stations separated by only a half mile in the Pacific-coast region, but there was a difference of 225 feet in ground elevation at the points involved. Here also, clearly, there was pronounced opportunity for air drainage to affect the situation.

A few years ago Dyke (4) studied local variations in minimum temperatures observed within the city of New Orleans, comparing the records obtained at the Weather Bureau office with those taken in Audubon Park, 5 feet above ground. He found the greatest difference in minima to be 16°. The same author examined records from the Weather Bureau office in Houston, Tex. (almost

300 feet above ground), and those from a station having standard ground exposure in open country at Harrisburg, Tex., about 35 miles away, but found no difference greater than 17° in minimum temperatures during the period studied.

A number of situations can be cited in which variations of 10° to 18° can be found between closely adjacent situations, especially between roof exposures at mid-city Weather Bureau stations as compared with nearby suburban records obtained from ground exposures, but no other case has been found with so much difference where air drainage is excluded.

Table 1 contains details for 14 dates on each of which the minimum temperature at Belle Chasse was 20° or more below that at the Weather Bureau office in New Orleans on the same morning. The average difference for these 14 dates is 22°. Shown also in this table are records for two additional ground level stations, Delta Farms and Houma, both located in the coastal delta region. Climatic and topographic conditions are much alike at all stations named. Delta Farms, like Belle Chasse, has a ground surface practically at sea level, and is on a tract under artificial drainage. The Houma station is located on ground about 10 feet above sea level.

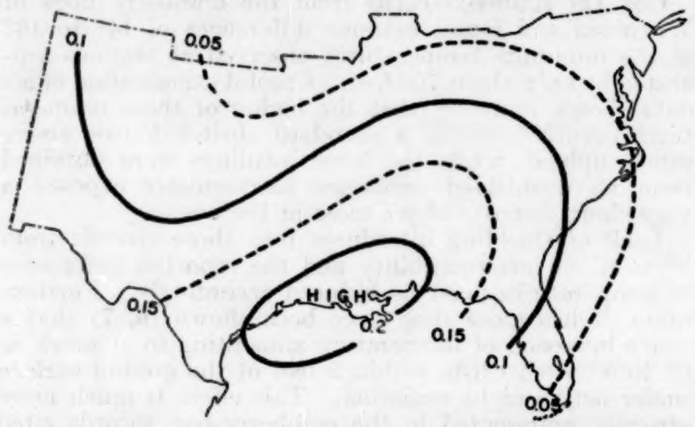

FIGURE 1.—Composite isobars for dates on which differences of 20° or more were developed between minimum temperatures at Belle Chasse and the Weather Bureau office, New Orleans, La.

The reliability of the Delta Farms record was somewhat dubious until the middle of 1938, but after that time there was opportunity for satisfactory comparison on 9 of the 14 dates. These give an average 17° below the minima for the same dates at New Orleans; this is 5° warmer than the average for Belle Chasse. The readings for Houma are taken on a cane plantation, and the soil of the area is a sandy loam. Good records at this station extend over the entire period covered by table 1, and the average depression of these minima in comparison with New Orleans is 16°, a difference almost identical with that shown for Delta Farms.

Houma lies 45 miles southwest of New Orleans, and Delta Farms is about halfway between that point and New Orleans. Both stations are located where there is no forest influence in the immediate surroundings. While unusually cold conditions are shown to develop with some frequency over a rather wide area near New Orleans, the most intense effects occur at Belle Chasse, which on some of these occasions had the lowest temperature officially recorded in the entire State of Louisiana on the given morning.

In order to have a still more complete setting for these selected occasions of unusually large abnormality in temperature, the whole period of the Belle Chasse records (44 months) was very carefully surveyed and the daily differences in minimum temperature as related to New Orleans were computed and tabulated.

Results are given in table 2, which shows Belle Chasse minima nearly 8° below those for the Weather Bureau office, for the year as a whole. The average monthly differences vary from 4° in January and February to 9° in October. Belle Chasse temperatures are 10° or more below the Weather Bureau office readings on 30 percent of all the days of record; and 8 percent of the time the difference is 15° or more. The occasions when Belle Chasse is 15° or more colder than New Orleans are strongly grouped in the last 3 calendar months, occurring about 1 day out of 5 in the period from October to December, inclusive. Ten of the fourteen cases of 20° differences listed in table 1 occurred in 2 months, October and November; all lie between October 19 and March 19.

Table 2 reveals a double seasonal arrangement, however, with lower values at midwinter and midsummer. (See fig. 3.) Higher values occur in 2 periods of 4 or 5 months each, centered roughly on spring and autumn. This is particularly evident in the columns showing the percentage of cases with 10° and 15° of depression in the Belle Chasse daily minima.

The general background for the more pronounced cases of cooling at Belle Chasse (listed by dates in table 1) can be best indicated by composite isobars from daily weather maps attending these occurrences. This composite is represented by figure 1, which shows the significant type condition, namely, a high-pressure area centered over southern Louisiana.

The individual weather charts from which figure 1 is generalized are more often characterized by a high-pressure ridge than by the localized center shown on the composite, but in nearly all cases the axis of the ridge lay east-west or northeast-southwest with the center line passing through Louisiana. It goes without saying that the individual high-pressure areas involved in these situations are of the continental and not the marine type. The most brilliantly clear skies at New Orleans occur with the advent of large masses of Pc air and winds of high velocity in the free air from a direction definitely north of west.

Another feature of the general weather situation should be mentioned. The extreme development of differences in night temperature at Belle Chasse as compared with New Orleans does not occur immediately upon establishment of true cold wave conditions, but is usually found on the second or even the third night of the cold spell, when temperatures at New Orleans have passed the lowest point. This of course is due to the part played by low wind movement in producing these local differences of temperature. It is only the calm conditions attending the central area of the anticyclonic formation that favor stratification of cold air at the earth's surface under clear night skies, which is necessary to establish the strong inversion of temperature involved in the situation.

To illustrate how completely the movement of wind at the low-level station enters as a control on radiation minima, two composite thermograph traces are shown in figure 2. These are somewhat idealized and simplified, but in character well represent the march of temperature on clear nights. The first section of this figure depicts the maximum effect of undisturbed radiation with very low wind movement and shows how under such conditions the temperature curve for Belle Chasse practically doubles the range of that for the Weather Bureau office. The lower

section of this figure shows at first the regular down-curve that is typical of the simple cumulative effect of outgoing radiation as it increases from early afternoon. The difference in temperature between thermograms at the two stations increases steadily until an increase in wind velocity to 4 or 5 miles per hour occurs at Belle Chasse; when this happens the temperature immediately rises there and the extreme difference in minima cannot thereafter be established, even though wind movement should again

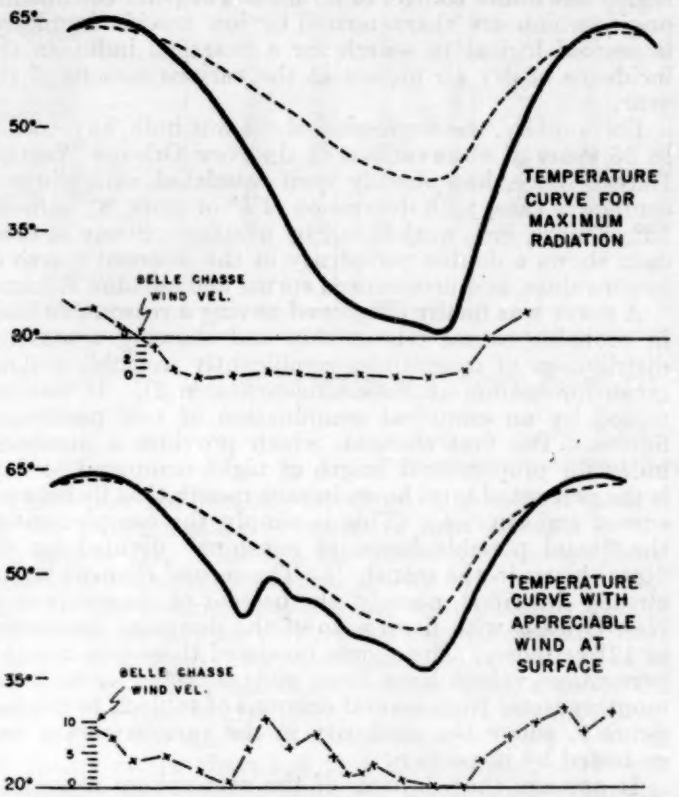

FIGURE 2.—Typical smoothed thermograms for New Orleans Weather Bureau office (dotted lines) and Belle Chasse substation (solid lines) representing in the upper half the extreme inversion produced under very calm night conditions, and in the lower half the effect of an increase in wind velocity to more than 4–5 miles per hour, on the march of night temperatures at Belle Chasse, other conditions being equal.

decrease and permit the Belle Chasse thermogram to resume the normal curvature for night radiation.

Both curves show a sharply increased rate of rise in the forenoon as compared with rate of cooling in the early night hours. This indicates how the night inversion of temperature (which, under extreme conditions is 20° to 25° in the 80 feet of difference in elevation of the two stations) breaks down with the first inception of morning turbulence, and warming proceeds by mixing combined with direct insolation. The new maximum is thus reached in about half the time required to establish the previous minimum temperature, indicating that mixing, under extreme conditions, can be as effective as insolation in the warming process.

Two questions are raised by these observations. These questions are: (*a*) Why are radiation minima at Belle Chasse 5° to 6° lower in the average than those at the similarly situated stations, Delta Farms and Houma; and (*b*) What is the explanation for the double seasonal period in radiational influence revealed by the monthly survey of difference in table 2?

In considering the first, we note that the high levee almost surrounding the area in which Belle Chasse is located has no counterpart at either of the other ground-level stations. This levee is certainly a significant factor in the observed localization of low-temperature effects near Belle Chasse, acting doubtless to conserve a pool of cold air.

There are, however, other physical differences in the environment of the three stations compared, that may be equally or perhaps even more significant. Belle Chasse stands in a locality that is, in the main, overgrown with high vegetation including much low forest of almost jungle density. In contrast, Delta Farms is surrounded by low-growing marsh vegetation, and at Houma the condition of the adjacent cane fields ranges from a bare cultivated surface in the early part of the year to the dense 10-foot growth of mature cane prior to harvest, near the end of the year.

Several investigators (1, 5) have called attention to the part played by different types of vegetative cover in producing variable effects upon night radiation and minimum air temperatures, but the role played by cover as distinct from type of soil has seldom been given any special emphasis.

Some unpublished temperature observations made by Arceneaux and Lauritzen at the United States Cane Experiment Station, Houma, La., which the present writer has been permitted to examine, indicate very strongly that night radiation at the level of the tops in full-grown stands of sugarcane produces on very still clear nights a peculiar stratification of the air, such that the temperature at the upper level is *lower* than that at the ground surface beneath. Later in the season, when the cane leaves have been killed by frost, this effect is no longer observable; at that time the lowest temperature within the same stand of cane occurs, not at the top but at the base of the plant.

Cornford (1) cites data (in his study of night temperatures in Britain) that directly confirm these observations by Arceneaux and Lauritzen. He states, for example, with reference to a stand of wheat, that "at 3 feet high it

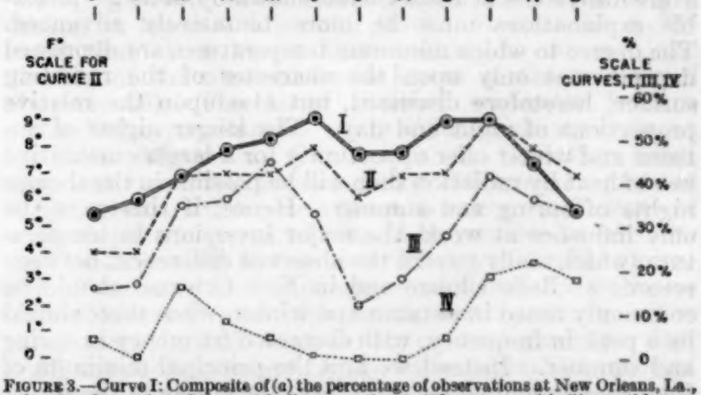

FIGURE 3.—Curve I: Composite of (*a*) the percentage of observations at New Orleans, La., showing depression of the wet bulb amounting to 12° or more, with (*b*) monthly percentage of total hours between sunset and sunrise (night hours) based on total hours in the month. Curve II: Mean daily difference between minimum temperatures at New Orleans and Belle Chasse. Curves III and IV: Percentage of days with minimum 10° or more colder (III), and 15° or more colder (IV) at Belle Chasse as compared with New Orleans Weather Bureau office records.

is colder over the wheat than over the (adjacent) bare soil. Between the stems of wheat the air is relatively warm." The temperature differences shown by his detailed data range from 0.7° to 1.7°.

The practically uninterrupted surface of dense green vegetation may therefore be assumed to act as the plane of maximum night cooling. Such green surfaces probably approach in effectiveness the rate of black body radiation. At Belle Chasse dense vegetation closely surrounds the

small acreage of cleared land on which the observing station is located, with an average top height estimated at 15 to 35 feet above ground level. If these tops become the coldest surfaces under night radiation there must be at least a slight tendency for the air from those levels to settle down into the adjacent clearing in the manner described in Cornford's studies (1). With very light air movement the coldest air should thus accumulate near the point of observation, located on agricultural land having relatively low cover. Such effects could not be expected in equal degree at Houma or Delta Farms due to lack of similar contrast in level of the vegetative surfaces from which nocturnal radiation proceeds.

The Louisiana delta region supports vegetation in remarkable profusion. Native plants are only partially deciduous and the rest period for annuals and deciduous perennials is quite short, confined mainly to the 2 months, January and February. When greenery is fully established there is hardly a square foot of overgrown area through which radiation can proceed directly to or from the soil surface. The usual influence of soil type and soil moisture as affecting night temperatures is thus lacking and there is instead the far more uniform and in general more effective radiation from an unbroken expense of green leaf surfaces acting somewhat like well insulated black to bring about nocturnal temperatures lower than similar weather situations can produce in less fertile regions.

It is interesting to note that the thermograms from Belle Chasse frequently show a slight dip in temperature just about sunrise, coincident with the first increase in air movement following a calm night. This drop in temperature appears to result from mixture of the air at the level of the recording thermometers (about 5 feet) with a colder stratum from some adjacent level, but whether from a lower or a higher source it is impossible with the data in hand to determine.

In seeking for the solution of the second problem—that of the double seasonal curve in frequency of larger temperature differences at Belle Chasse shown by table 2—probable explanations must be more tentatively advanced. The degree to which minimum temperatures are depressed depends not only upon the character of the radiating surface, heretofore discussed, but also upon the relative proportions of night and day. The longer nights of autumn and winter offer opportunity for a larger cumulative loss of heat by radiation than will be possible in the shorter nights of spring and summer. Hence, if this were the only influence at work, the major inversions in temperature (which really govern the observed differences between records at Belle Chasse and in New Orleans) should be commonly noted in autumn and winter, when there should be a peak in frequency, with decreased frequency in spring and summer. Instead we find the principal minimum of frequency in midwinter and a secondary peak in the spring and early summer.

This might be partially attributed to loss of green cover by winter-killing during the coldest time of the year, with a rapid recovery in spring. The greater differential cooling at Belle Chasse in summer (when the average difference in daily minimum as compared with New Orleans amounts to 6° or 7° in contrast with the value of 4° in midwinter) argues for the effectiveness of green vegetation in producing this midsummer excess. However, this line of reasoning does not explain the spring peak, as there is no peak in vegetative cover at that season.

Some additional factor or factors must therefore be sought having a variability in the year similar to that of the data under examination. Recalling the fact that the major temperature differences were recorded when the region was under control of air masses of polar continental origin, which are characterized by low specific humidity, it seemed logical to search for a practical index to the incidence of dry air masses at the various seasons of the year.

Fortunately, the depression of the wet bulb, as recorded in 35 years of observations at the New Orleans Weather Bureau office, had already been tabulated with the percentage of cases with depression of 5° or more, 8° or more, 12° or more, etc., worked out by months. Study of these data shows a double periodicity in the seasonal march of larger values, and pronounced spring and autumn maxima.

A curve was finally developed having a reasonable basis in probable causal relationship and showing a seasonal distribution of magnitudes significantly resembling those given for cooling at Belle Chasse (table 2). It was obtained by an empirical combination of two percentage figures. The first element, which provides a numerical index for proportional length of night compared to day, is the percent of total hours in each month that lie between sunset and sunrise. (This is simply the complement of the "total possible hours of sunshine" divided by the "total hours in the month.") The second element is that already described, namely, the percent of observations at New Orleans with depression of the dewpoint amounting to 12° or more. The simple means of these two monthly percentage values have been plotted, together with the monthly items from several columns of table 2, to produce figure 3, where the similarity in the various curves may be tested by inspection.

It appears that dryness of the atmosphere is quite as important as length of night in lowering noctural temperatures near the earth's surface.

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TABLE 1.—*Comparison of minimum temperature observations at Belle Chasse, La., and 2 additional ground-level stations, with the minimum at New Orleans Weather Bureau office as the basis for comparison, on 14 dates when Belle Chasse was 20° or more below New Orleans*

Date	Minimum temperature, New Orleans	Belle Chasse		Delta Farms		Houma	
		Minimum	Difference	Minimum	Difference	Minimum	Difference
	°	°	°	°	°	°	°
Nov. 30, 1935	49	29	20	?	--------	36	13
Oct. 19, 1936	64	43	21	?	--------	49	15
Dec. 23, 1936	50	26	24	?	--------	33	17
Mar. 19, 1938	68	45	23	?	--------	57	11
Oct. 25, 1938	55	32	23	36	19	39	16
Oct. 26, 1938	55	34	21	36	19	40	15
Oct. 29, 1938	59	39	20	44	15	43	16
Oct. 30, 1938	60	38	22	44	16	42	18
Nov. 10, 1938	48	26	22	34	14	32	16
Nov. 21, 1938	52	31	21	36	16	36	16
Nov. 29, 1938	40	16	24	23	17	24	16
Nov. 30, 1938	43	18	25	24	19	27	16
Dec. 6, 1938	47	23	24	29	18	32	15
Jan. 20, 1939	47	27	20	?	--------	29	18
Average depression of minimum below New Orleans	--------	--------	22	--------	17	--------	16

TABLE 2.—*Tabulation of daily differences in minimum temperature at Belle Chasse compared with those at the Weather Bureau Office in New Orleans. (All temperatures at Belle Chasse are lower than those with which they are compared.) Based on 44 months of record; 1935–39*

Month	Average monthly depression of minima at Belle Chasse	Percentage of daily observations with the minimum temperature at Belle Chasse—		
		10° or more below New Orleans	15° or more below New Orleans	20° or more below New Orleans
	°F.	Percent	Percent	Percent
January	4	16	5	1
February	4	17	0	0
March	7	35	16	1
April	7	37	8	0
May	7	45	5	0
June	8	33	1	0
July	6	12	0	0
August	7	18	0	0
September	7	28	5	0
October	9	42	19	5
November	8	37	22	4
December	7	34	18	4
Annual average	7.6	30	8	1

RADIATIVE COOLING IN THE LOWER ATMOSPHERE

By WALTER M. ELSASSER

[California Institute of Technology and U. S. Weather Bureau, August 1940]

The writer has recently developed a graphical method for the determination of radiative heat transfer in the atmosphere (1). This is a modification of the graphical method introduced some years ago by Mügge and Möller (2). In this method moisture and temperature values of a given atmosphere are plotted on a printed diagram (later referred to as Radiation Chart) and the radiative flux at any level can be obtained by evaluating an area on the chart. The results given below represent the first practical tests of our chart. A comprehensive paper covering the theory of the chart has just been published (1) and we shall therefore omit references to the theoretical foundations of this work and confine ourselves to a communication of the results.*

I. FREE AIR COOLING

We used airplane observations of free air moistures and temperatures. The stations selected (with the exception of Fort Smith, Northwest Territory) are located in two north-south cross sections over the United States. The mean values of February 1937 and of August 1937 served as basis for these calculations. The cooling calculated represents the mean cooling in layers 1 kilometer thick due to the long-wave radiation of water vapor (the cooling due to carbon-dioxide radiation is found negligible). The procedure of evaluating the cooling was as follows. First, specific humidity (with a pressure correction applied, see below) was plotted against pressure. The points were joined by a curve and the total amount of moisture between successive levels, 1 kilometer distant, was determined by means of a planimeter. These values of total moisture were then plotted against temperature on the radiation chart. It is usually possible to plot, on the same chart, curves corresponding to several or to all levels of one station. The area contained between curves representing successive levels measures the heat loss of the layer between them; this loss divided by the heat capacity of the layer gives the net cooling.

*Part of the calculations was carried out by A. C. Gibson of the U. S. Weather Bureau, now at Jacksonville, Fla.

There is still a certain doubt about the manner in which the air pressure affects the radiative properties of water vapor. According to a theoretical formula (3) the absorption should be proportional to the pressure, while F. Schnaidt (4) derives from measurements of G. Falckenberg (5) the result that the absorption is proportional to the square root of the air pressure. The latter view is sustained by other, yet unpublished, experiments carried out by John Strong at the California Institute of Technology. We therefore used the square root pressure correction in our computations.

The figures in table 1 represent mean values of the cooling in layers 1 kilometer thick. It is to be understood that these layers have nothing to do with the division of the atmosphere in layers in the manner of Simpson (6). The latter division originates from a method of approximation where differentials are replaced by finite differences. Our figures, on the other hand, represent rigorous solutions of the differential equations of radiative transfer, once the absorption coefficients of water vapor are given. It would be possible to calculate the "local" cooling at any given level, but the determination of the mean cooling of a layer of reasonable thickness is less laborious and also much more accurate. The values given in table 1 are in degrees centigrade per day.

All the cooling values contained in table 1 are plotted in figure 1 with the decadic logarithm of the specific humidity as abscissa. The oblique line represents the empirical relation

$$(\Delta T)_{day} = 1 + 2 \log_{10} w \qquad (1)$$

The two dashed lines are set off from the main line by 0.4° on each side. It is seen that the large majority of the points falls within these boundaries. The major deviations seem to occur in the lowest kilometer; the points representing these layers are indicated by rings in figure 1. The cause of this decrease in cooling is presumably to be found in the relatively lower mean temperature of the lowest kilometer due to the influence of the nocturnal

ground inversion. Caution should therefore be used in the application of formula (1) to meteorological problems. We think, however, that (1) is a workable approximation for average conditions in middle latitudes and in the lower middle troposphere. It should not be extrapolated to other conditions without new checks by direct application of the chart.

II. CLOUD COOLING

If the curves representing the moisture-temperature relations are drawn on the radiation chart, it is easy to determine the amount of heat which a black surface located at any level of the atmosphere gains or loses if it radiates upward or downward. As the base and the top of a cloud represent such black surfaces one can readily obtain the mean cooling of a cloud. There is usually a gain of heat at the base and a loss at the top of a cloud, the latter being by far the larger. In table 2 figures representing the gain at a cloud base and the loss at a cloud top located at the levels indicated are given in calories per 3 hours.

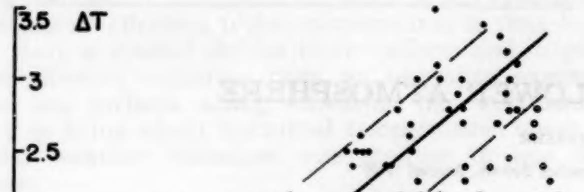

FIGURE 1.

It is seen that the net loss for a cloud of 1 kilometer thickness runs very near to 30 calories per 3 hours; only for clouds in the lowest kilometer the values are somewhat lower. The following formula gives a fairly good estimate of the cooling of a cloud under average conditions:

$$(\Delta T)_{day} = \frac{1{,}000}{d} \tag{2}$$

Here d is the thickness of the cloud expressed in millibars and the cooling is given in degrees centigrade per day. Formula (2) applies under about the same conditions and the same restrictions as fomula (1) for the free-air cooling.

It must be said here that the moisture distribution in the mean soundings is of course such that no clouds would be expected, as the relative humidity nowhere reaches 100 percent. Our calculations show, however, that the cooling values are rather insensitive to small changes in moisture and the values in table 2 would therefore only change by a few percent if in place of the mean soundings we substituted soundings in which the humidity actually goes up to 100 percent at the cloud. A similar argument may also be applied to the free-air cooling as given in Table 1. If we wanted to obtain the actual mean cooling, we would have to use the mean of only those soundings which correspond to a cloudless sky. As this would not be very different from the over-all monthly mean, we introduce only a small error by using the latter throughout our calculations.

Table 3 contains the values of the heat loss at the ground for a cloudless sky computed in the same manner.

III. RADIATIVE HEAT TRANSFER IN NOCTURNAL GROUND INVERSIONS

In the calculations for table 1 it was assumed *that the ground itself has the same temperature as the air near the ground* whose temperature is indicated in the soundings. Actually, during the night the ground temperature will sink below that of the air in the lowest layers and this phenomenon will intensify the formation of ground inversions. Calculations which give the order of magnitude of this effect are summarized in table 4. It was found convenient to calculate for a number of typical cases rather than for selected individual records. The first two lines of table 4 give the temperatures and specific humidities in the air near the ground for which the calculations were carried through. Assume for a moment that the ground and a layer of air have the same temperature. A certain amount R of radiation emitted by the ground is absorbed by the air near the ground. If there is a temperature difference between the two radiations, a net flux of heat

$$F = \delta T \frac{dR}{dt}$$

will take place. The quantity dR/dT can be obtained from the chart (it is equal to the area of a strip bounded by 2 isotherms distant by 1° and by 2 moisture isopleths which correspond to the bottom and to the top of the layer). Since the layers are rather thin, it is necessary to calculate also the heat flux due to the radiation in the carbon-dioxide band. Schnaidt (4) gives a curve for the absorption of CO_2 radiation as function of the thickness. The experimental data were corrected by him so that this final curve refers to a condition where both the emitting black body and the absorbing layers are at the same temperature of 0° C. According to Schnaidt, about 8 percent of the total radiation of a black body of 0° C. is absorbed by the CO_2 in the first 100 m. of air and about 6 percent more by the CO_2 in the next following 300 m., while beyond this distance there is very little additional absorption. These figures refer to the absorption of a straight beam; the corresponding values for diffuse radiation are obtained approximately by taking half the thicknesses for the same percentual absorption. Let R' be the amount of radiation in the CO_2 band which is exchanged between the ground and any layer of air of the same temperature as the ground; further, put $R' = a\, I'$ where I' is the spectral intensity of black body radiation at the center of the CO_2 band and a a numerical factor. We have then for the heat transfer due to carbon-dioxide radiation

$$F = \delta T \frac{dR'}{dT} = \delta T \cdot a \frac{dT'}{dT} = \delta T \frac{R'}{T'} \cdot \frac{dT'}{dT}$$

Now the quantity $dI'/I'\, dT$ can immediately be calculated from Planck's law while R' is given by the figures quoted above. We now calculate the net cooling of the air which will be

$$\text{Cooling} = \frac{\delta T}{C}\left(\frac{dR}{dT} + \frac{R'}{T'}\frac{dT'}{dT}\right) \tag{3}$$

where C is the heat capacity of the layer. We assume that the layer is homogeneous in temperature; then δT represents the difference between the temperature of the layer

and that of the ground. The numerical results obtained from formula (3) for various temperatures and corresponding moistures are summarized in table 4. The values given in the last two lines are the values of the factor of δT in (3); multiplied by δT they give the actual cooling in these layers in an interval of three hours. The same figures can of course also be applied to compute the radiative part of the heating of the air near the ground during the day when the ground temperature is higher than the air temperature.

The results contained in table 4 indicate that radiative exchange of heat between the ground and the atmosphere is concentrated in the lowest 50 meters and is very small above this height. The observed ground inversions are often of the order of 1 kilometer and if the total heat exchange for both layers (which is between 0.3 and 0.5 calorie per degree temperature difference of air and ground) is distributed over the height of the inversion, the resulting decrease in temperature is extremely small. Only during the polar night where the ground temperature can fall much below the temperature of the air, does this mechanism of radiative transfer produce an appreciable effect, as has been pointed out by Wexler (**8**). We must conclude that the ordinary nocturnal inversion is almost exclusively of turbulent origin so far as the transfer of heat from the ground to the air is concerned. It is of course of radiative origin in the sense that the heat loss of the ground itself is of a purely radiative nature.

IV. CONCLUSIONS

The results given above show that the radiative cooling in the free air and in absence of clouds is confined within rather narrow limits. Roughly, it is of the order of 1° per day in air masses of polar type and of the order of 2° to 3° per day in air masses of equatorial type. Furthermore, it appears clearly that there is no indication of a heating of the atmosphere by radiation. *With regard to long-wave radiation the atmosphere is a cold source throughout.* This result has already been reached by Mügge and Möller (**2**) and by Albrecht (**9**). Apart from the heat of condensation, all the heat lost by radiation of the atmosphere must therefore be supplied by turbulent exchange and by convection (frontal, cyclonic, and local). It may appear rather surprising at first sight that the lapse rate in the free atmosphere is not much more frequently superadiabatic and that local convection does not play a much larger role than is actually observed. In this connection we might notice, however, that the rate of cooling above 2 kilometers decreases steadily with height and we might presume that this decrease continues beyond 5 kilometers, where our calculations end. In the course of several days this must lead to an appreciable stabilization of the lapse rate in the middle troposphere. Since radiative cooling acts continuously everywhere, it probably constitutes also itself the major stabilizing factor in the atmosphere.

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TABLE 1.—*Cooling of 1-km. layers in ° C. per day for cloudless sky—monthly means*

Station, month	Grd.		1 km.		2 km.		3 km.		4 km.		5 km.
Fort Smith, Northwest Territory, February 1937:											
Temperature	−23.3		−16.1		−16.7		−21.4		−26.6		—
Specific humidity	.6		.9		.8		.6		.4		—
Cooling		0.7		1.1		0.9		0.5		—	
Fargo, N. Dak., February 1937:											
Temperature	−16.5		−11.0		−11.0		−14.9		−20.6		−26.8
Specific humidity	.8		1.4		1.3		1.0		.6		.4
Cooling		0.7		1.3		1.4		1.1		0.5	
Omaha, Nebr., February 1937:											
Temperature	−7.3		−6.0		−6.8		−10.9		−16.3		−22.9
Specific humidity	1.8		1.9		1.6		1.3		.9		.6
Cooling		1.0		0.8		1.3		1.2		1.1	
Oklahoma City, Okla., February 1937:											
Temperature	.9		2.8		1.6		−3.8		−9.5		−16.0
Specific humidity	3.0		2.8		2.1		1.6		1.1		.8
Cooling		1.6		1.7		1.7		1.2		1.2	
San Antonio, Tex., February 1937:											
Temperature	7.8		10.2		8.2		3.9		−2.0		−8.2
Specific humidity	5.2		5.4		4.4		3.2		2.3		1.6
Cooling		1.9		2.4		1.9		1.8		1.8	
Sault Ste. Marie, Mich., February 1937:											
Temperature	−10.1		−9.5		−11.9		−15.6		−21.0		−27.4
Specific humidity	1.4		1.6		1.2		1.0		.7		.5
Cooling		1.0		1.0		1.3		0.8		0.9	
Detroit, February 1937:											
Temperature	−3.6		−4.4		−6.7		−10.9		−16.1		−21.9
Specific humidity	2.3		2.1		1.4		1.2		.9		.7
Cooling		1.2		1.1		1.2		1.0		0.9	
Dayton, Ohio, February 1937:											
Temperature	−2.4		−2.9		−4.6		−8.7		−13.6		−19.8
Specific humidity	2.5		2.4		1.6		1.2		1.1		.9
Cooling		1.3		1.3		1.2		0.9		0.8	
Nashville, Tenn., February 1937:											
Temperature	4.6		2.6		−.1		−4.4		−9.4		−15.1
Specific humidity	3.8		3.3		2.4		1.7		1.3		1.0
Cooling		1.8		1.6		1.8		1.4		1.1	
Montgomery, Ala., February 1937:											
Temperature	7.5		5.9		2.6		−.4		−5.2		−10.9
Specific humidity	4.4		3.3		2.6		1.7		1.5		1.0
Cooling		1.9		1.7		1.3		1.3		1.2	
Pensacola, Fla., February 1937:											
Temperature	8.7		9.1		5.7		2.1		−3.3		−8.8
Specific humidity	6.4		6.0		4.8		3.2		2.1		1.6
Cooling		1.9		2.2		2.1		1.6		1.8	
Miami, Fla., February 1937:											
Temperature	16.3		14.8		11.3		6.0		1.0		−4.0
Specific humidity	9.8		8.6		5.4		4.3		3.4		2.7
Cooling		2.2		2.2		2.1		1.9		1.6	
Fargo, N. Dak., August 1937:											
Temperature	18.9		22.2		17.5		10.8		4.1		−3.1
Specific humidity	11.3		9.3		6.7		4.7		3.5		2.7
Cooling		2.7		3.0		2.6		2.6		1.7	
Omaha, Nebr., August 1937:											
Temperature	23.1		24.7		19.5		12.6		6.0		−.7
Specific humidity	14.4		12.4		9.2		7.2		4.8		3.2
Cooling		2.8		3.2		2.8		3.0		2.5	
Oklahoma City, Okla., August 1937:											
Temperature	24.6		26.3		19.6		11.9		5.0		−1.8
Specific humidity	14.7		12.8		10.7		8.1		5.4		3.1
Cooling		2.7		3.1		3.4		3.5		2.5	
San Antonio, Tex., August 1937:											
Temperature	25.2		23.7		16.9		10.3		4.2		−1.0
Specific humidity	15.7		12.2		9.6		6.1		4.0		2.7
Cooling		2.4		2.9		2.8		2.4		1.7	
Sault Ste. Marie, Mich., August 1937:											
Temperature	16.1		18.2		13.5		8.1		2.2		−4.1
Specific humidity	10.4		9.2		7.0		4.5		3.0		2.0
Cooling		2.4		3.0		2.7		2.5		1.9	
Detroit, August 1937:											
Temperature	19.6		19.5		13.6		8.3		2.6		−3.2
Specific humidity	12.8		9.4		7.0		4.6		3.2		2.3
Cooling		2.8		2.7		2.5		2.4		1.8	
Dayton, Ohio, August 1937:											
Temperature	19.2		21.5		15.3		10.2		4.4		−1.4
Specific humidity	13.0		12.1		8.7		5.0		3.3		2.2
Cooling		2.6		3.3		3.1		2.5		1.6	
Nashville, Tenn., August 1937:											
Temperature	22.8		21.9		15.5		9.3		3.9		−1.6
Specific humidity	14.6		13.0		9.4		6.4		4.1		2.6
Cooling		2.2		3.0		2.9		2.8		1.8	

TABLE 1.—*Cooling of 1-km. layers in ° C. per day for cloudless sky—monthly means*—Continued

Station, month	Grd.	1 km.	2 km.	3 km.	4 km.	5 km.
Montgomery, Ala., August 1937:						
Temperature	24.5	21.2	14.7	8.9	3.3	−1.7
Specific humidity	16.7	12.8	9.5	7.0	5.3	3.7
Cooling		2.3	2.4	2.3	2.2	2.0
Pensacola, Fla., August 1937:						
Temperature	23.8	20.8	15.1	9.4	3.8	−1.4
Specific humidity	17.2	13.8	9.7	6.9	5.2	3.7
Cooling		2.2	2.8	2.4	2.3	2.1

TABLE 2.—*Heat gain at cloud base and heat loss at cloud top in calories per cm² per 3 hours—same mean monthly soundings as table 1*

Station	1 km.	2 km.	3 km.	4 km.	5 km.
Fort Smith, Northwest Territory: February 1937:					
Gain base	−4.0	−3.2	−0.2	2.4	-------
Loss top	29.0	31.8	31.1	30.7	-------
Fargo, N. Dak.:					
February 1937:					
Gain base	−3.3	−3.0	−.6	3.6	7.4
Loss top	29.3	33.2	33.9	33.6	31.6
August 1937:					
Gain base	−2.3	1.6	5.9	10.1	14.3
Loss top	27.7	32.8	35.8	37.9	37.6
Omaha, Nebr.:					
February 1937:					
Gain base	−1.0	−.2	2.4	5.0	9.8
Loss top	31.1	33.0	33.9	33.3	32.1
August 1937:					
Gain base	−1.0	2.9	6.8	10.5	14.5
Loss top	24.2	29.8	33.7	36.8	37.9
Oklahoma City, Okla.:					
February 1937:					
Gain base	−1.3	−.1	3.8	7.3	11.4
Loss top	32.2	36.8	38.9	37.3	36.1
August 1937:					
Gain base	−1.0	3.6	7.4	11.4	14.8
Loss top	23.8	28.7	33.2	38.5	40.5
San Antonio, Tex.:					
February 1937:					
Gain base	−2.1	.3	3.0	7.0	10.9
Loss top	28.6	33.6	37.3	33.5	37.6
August 1937:					
Gain base	1.0	5.1	8.6	11.9	14.6
Loss top	25.0	29.8	33.9	37.9	39.4
Sault Ste. Marie, Mich.:					
February 1937:					
Gain base	−.3	1.1	3.5	6.8	10.4
Loss top	30.1	32.1	33.0	32.0	30.5
August 1937:					
Gain base	−1.4	2.3	5.6	8.9	12.9
Loss top	26.3	31.7	34.7	37.7	37.9
Detroit:					
February 1937:					
Gain base	.5	1.9	4.4	7.6	11.0
Loss top	30.1	32.1	33.0	32.0	30.5
August 1937:					
Gain base	0	4.0	7.1	10.1	13.5
Loss top	26.6	31.0	35.0	37.7	38.4
Dayton, Ohio:					
February 1937:					
Gain base	.3	1.4	4.0	7.2	10.6
Loss top	29.9	33.2	34.2	33.3	31.7
August 1937:					
Gain base	−1.6	2.8	5.8	9.4	13.0
Loss top	25.5	31.4	36.5	39.3	41.4
Nashville, Tenn.:					
February 1937:					
Gain base	1.3	3.1	5.9	8.7	12.2
Loss top	30.9	34.3	35.7	36.0	35.5
August 1937:					
Gain base	.8	4.5	7.9	10.7	13.5
Loss top	23.3	28.7	33.3	37.5	38.6
Montgomery, Ala.:					
February 1937:					
Gain base	1.0	3.3	5.2	8.0	11.7
Loss top	31.7	35.0	37.3	37.6	36.7
August 1937:					
Gain base	2.0	5.6	8.4	10.8	13.2
Loss top	22.9	27.0	30.9	34.2	36.3

TABLE 2.—*Heat gain at cloud base and heat loss at cloud top in calories per cm² per 3 hours—same mean monthly soundings as table 1*—Con.

Station	1 km.	2 km.	3 km.	4 km.	5 km.
Pensacola, Fla.:					
February 1937:					
Gain base	−.2	2.1	4.5	7.7	10.2
Loss top	26.7	31.2	34.8	35.3	37.1
August 1937:					
Gain base	1.6	4.6	7.7	10.2	12.7
Loss top	21.7	26.4	30.2	33.5	35.8
Miami, Fla.: February 1937:					
Gain base	.9	3.6	6.3	9.3	11.9
Loss top	26.0	30.7	33.1	34.9	38.0

TABLE 3.—*Nocturnal heat loss of the ground in calories per cm² per 3 hours for cloudless sky—based on same mean soundings as above*

Fort Smith, February	22.8
Fargo:	
February	24.0
August	19.1
Omaha:	
February	27.3
August	18.0
Oklahoma City:	
February	27.5
August	17.9
San Antonio:	
February	21.4
August	18.8
Sault Ste. Marie:	
February	28.8
August	18.6
Detroit:	
February	26.8
August	19.6
Dayton:	
February	26.5
August	17.4
Nashville:	
February	26.9
August	18.2
Montgomery:	
February	26.5
August	18.3
Pensacola:	
February	19.7
August	15.9
Miami:	
February	19.3

TABLE 4.—*Differential radiative cooling of lowest strata per degree temperature difference between the layer and the ground—add to free cooling values of table 1*

Temperature / Specific humidity } assumed	−20° / 1	−10° / 2	0° / 3	+10° / 6	+20° / 10
0–50 m.					
Water, cal./cm.²/3 hr	12.0	15.9	20.5	27.6	$35.9\cdot10^{-3}$
CO_2, cal./cm.²/3 hr	9.8	9.2	8.6	7.9	$7.3\cdot10^{-3}$
50–200 m.					
Water, cal./cm.²/3 hr	4.3	5.5	6.5	7.9	$10.5\cdot10^{-3}$
CO_2, cal./cm.²/3 hr	7.4	6.9	6.4	5.9	$5.5\cdot10^{-3}$
Differential cooling in °C. per 3 hours					
0–50 m	.13	.16	.19	.24	.30
50–200 m	.023	.025	.027	.030	.036

METEOROLOGICAL AND CLIMATOLOGICAL DATA FOR JULY 1940

[Climate and Crop Weather Division, J. B. KINCER in charge]

AEROLOGICAL OBSERVATIONS

By EARL C. THOM

The mean surface temperatures during July were above normal over a large part of the country. Mean temperatures below normal occurred in parts of Texas and Oklahoma, over the Gulf States, the South Central States and in a narrow strip of the Central Atlantic region. Nebraska and South Dakota, together with eastern North Dakota and northwestern Minnesota, had mean temperatures from 6° to 8° F. above normal for the month, while a small area in northeastern Texas recorded a mean temperature 4° below normal.

At the 1,500 m. level the direction of the resultant winds was south of the normal resultant direction (counterclockwise turning) over most of the country. At this level the opposite turning of the resultant wind, indicating the total mass transport of air from more northerly latitudes than usual during the month, was noted over a portion of the South Central States and the west Gulf States and at separate localities in the northwestern mountain region and along the upper Atlantic coast. The same shift in the direction of the resultant winds occurred at 3,000 meters. No well-defined tendencies were noted when the direction of the 5 p. m. (E. S. T.) resultant winds at the 5,000 m. level were compared with the corresponding 5 a. m. normals for the month.

The 5 a. m. resultant velocity for July at the 1,500 m. level was higher than normal along the Pacific coast, over the Southwest and over the West Central States and below normal over the rest of the country. At 3,000 meters the 5 a. m. resultant velocities for the month were below normal over most of the northern half of the country and were above normal to the southward. Except at scattered stations the 5 p. m. resultant velocities were higher than the corresponding 5 a. m. normals at the 5,000 m. level.

It is interesting to note that again in July most of the country which recorded above normal surface temperatures also showed resultant winds at the 1,500 m. level from directions more southerly than is normal for the month. This tendency is also shown clearly at the 3,000 m. level. In the 2 previous months this relation between the mean surface temperature and the direction of the resultant winds for the month was not in evidence at this higher level.

At the 1,500 m. level during July the directions of the resultant winds at 5 p. m. were in general considerably south of their direction at 5 a. m. (counterclockwise turning). At the 3,000 m. level the resultant winds shifted to the southward during the day over the northwestern and north-central parts of the country, but showed a shift to northward generally over the rest of the country.

At the 1,500 m. level the resultant velocity for the month of July was lower at 5 p. m. than at 5 a. m. over most of the country, this velocity having increased during the day only over the Great Lakes and over the Northwest. At the 3,000 m. level the same changes in resultant velocity were noted except that the increase in velocity extended over Montana and over the North Central States.

At the levels from 4,000 meters up to at least 17,000 meters the highest mean monthly pressures occurred over Phoenix, Ariz., and the lowest over Sault Ste. Marie, Mich. However, at the 6,000 m. level, Buffalo and Sault Ste. Marie both had the same mean monthly pressure, 483 mb. At the 1,000, 2,000, and 3,000 m. levels, Atlantic Station No. 2 had higher mean monthly pressure than any station in the United States. At the 1,000 m. level, for example, the mean pressure at Atlantic Station No. 2 was 914 mb., while the highest for the United States at this level was 910 mb., at Miami and at Norfolk, and the lowest was 901 mb. at Boise, Idaho. At Phoenix, Ariz., where the pressure was maximum at higher levels, a low mean pressure of 902 mb., was recorded at 1,000 meters and a relatively low pressure of 806 mb. at 2,000 meters. Mean pressures were in general lower for all upper levels at more northerly latitudes. At the 10,000 m. level, for example, mean pressures were 291 mb. at Phoenix, 273 mb. at Sault Ste. Marie, 270 mb. at Fairbanks, and 266 mb. at Juneau.

Mean monthly pressures were generally higher during July than during June at all levels from the surface to at least the 14,000 m. level. With only occasional isolated exceptions this was true over all of the United States, over Fairbanks and Juneau and over both Atlantic stations. This increase in mean pressure over that of the preceding month was considerable, amounting, for example, to an average of 7 mb. over the Great Lakes at the 1,000 m. level.

The greatest difference in mean pressure occurred at the 8,000, 9,000, and 10,000 m. levels, at each of which there was a difference of 18 mb. between the pressure at Phoenix and that at Sault Ste. Marie. The steepest mean pressure gradients during the month were found between Sault Ste. Marie and Washington, D. C., and between Sault Ste. Marie and Omaha. In the latter case there was an average difference of 13 mb. in pressure along the 9,000 m. level within a horizontal distance of about 700 miles.

At the levels below 10,000 meters the mean temperatures in July were higher than in June at Fairbanks and Juneau and at both Atlantic stations. This increase in temperature was also generally true over the United States except in the Great Lakes region and in part of the East Central States, where temperatures at these levels were somewhat lower than in June. At most of the levels above 10,000 meters the changes in mean temperature were well distributed. However, at the three levels, 15,000, 16,000, and 17,000 m., the mean temperature was lower than in June over the Rocky Mountain and Plateau region, the average temperature for these levels being about 4° C. lower at Albuquerque than in the preceding month.

At the 1,000 and 2,000 m. levels, lower mean temperatures were recorded over most of the country than were observed during the corresponding month in 1939. At these levels temperatures were warmer for July this year than last only at El Paso and at Miami, over the Northwest and extreme west and along the central Atlantic coast. Only Spokane and El Paso were warmer than last year at all of the next three higher levels, all other stations being in general cooler at these levels.

The altitude of the level of mean freezing temperature in July was higher in general over the western half of the country than over the eastern half. This level of 0° C. was lowest over Sault Ste. Marie, about 2,900 meters, and was highest over Phoenix, 5,300 m. The level of freezing rose rapidly to the southward over the eastern part of the country, being 3,900 m. at Joliet, 4,300 m. at Nashville, and 4,700 m. at Pensacola. Over most of the country the level of freezing was several hundred meters higher than

in June; however, the level of freezing was about 300 m. lower than in June over the eastern Great Lakes.

The lowest free-air temperature at standard levels in July was −76.9° C. (−106.4° F.) recorded at El Paso at the 17,000-meter level. Minimum temperatures lower than −70.0° C. (−94.0° F.) occurred in the free air during the month over all of the United States south of 35° N.; while all free-air minimum temperatures in the area north of 45°, except at Lakehurst, were higher than −69° C. (−92.2° F.). At Juneau, Alaska, the lowest temperature recorded in July was −58.4° C. (−73.1° F.) at 11,000 meters above sea level.

Table 3 shows the maximum free-air wind velocities and their directions for various sections of the United States during July, as determined by pilot-balloon observations. The extreme maximum for the month was 65.2 meters per second (145.8 miles per hour) observed on July 4 at Washington, D. C. This high-velocity wind was blowing from the WSW at an altitude of 9,860 meters (over 6 miles) above sea level. This velocity, however, was 18.8 meters per second (42 miles per hour) lower than the extreme velocity observed in July 1939.

Tropopause data for July showing the mean altitude and temperature of the tropopause at various stations are shown in table 4 and on chart XIII.

MEAN MONTHLY ISENTROPIC CHART [1]

The dominant features on the mean monthly isentropic chart (Θ=314° A.) for July 1940, are the typical summertime anticyclonic eddy over the South Central States, and the moist tongue over the Gulf coast. Assuming that the chart, although based only on data for the first half of the month, was representative in its broad aspects of conditions for the entire month, the large excess of precipitation over the Gulf coast may be related to the moist tongue which prevailed there, and perhaps the deficiencies which lie southwest of the lakes were caused by the dry tongue associated with the anticyclonic eddy. The above normal precipitation in the northwest was probably not caused by motion in the 314° A. surface during the first half of July.

NOTE.—During the month of July radiosonde observations were made only during the first 13 days of the month at all Weather Bureau stations. Similar observations were made during the full month at the six Navy stations and at the two Atlantic stations. Data shown on tables 1 and 4, and data used in the above discussion of aerological observations, are based on all observations. Temperature and pressure data for the six Navy stations used in the preparation of all charts (VIII to XIII) have, however, been recomputed to include only the first 13 days of July.

[1] Prepared by the Research Division.

TABLE 1.—*Mean free-air barometric pressure (P.) in millibars, temperature (T.) in degrees Centigrade, and relative humidities (R. H.) in percent, obtained by airplanes and radiosondes during July 1940*

Stations and elevations in meters above sea level

Altitude (meters) m. s. l.	Albuquerque, N. Mex. (1,620 m.)				Atlanta, Ga. (300 m.)				Billings, Mont. (1,089 m.)			
	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.
Surface	13	842	23.0	43	12	984	19.8	88	14	893	21.6	51
500					12	962	19.7	83				
1,000					12	908	18.2	76				
1,500					12	856	16.1	75	14	852	20.7	49
2,000	13	806	22.3	40	12	807	13.3	77	14	803	18.3	47
2,500	13	760	18.8	39	12	760	10.2	78	14	758	15.0	49
3,000	13	717	15.2	42	11	716	7.3	79	14	714	11.4	53
4,000	13	636	7.3	51	10	634	1.8	80	14	633	3.9	60
5,000	13	563	−0.7	60	10	559	−3.7	78	14	559	−3.7	67
6,000	13	496	−8.3	66	10	492	−9.5	76	14	491	−11.0	66
7,000	13	435	−14.8	64	10	432	−15.7	71	14	431	−18.0	63
8,000	13	381	−22.0	64	9	378	−22.7	73	14	376	−25.5	60
9,000	13	331	−29.4	62	9	329	−30.3	69	14	327	−33.6	58
10,000	13	288	−37.0	60	9	285	−38.4	64	14	283	−42.2	
11,000	13	248	−44.6		9	246	−46.8		14	244	−50.8	
12,000	12	213	−52.3		9	211	−54.6		14	208	−58.3	
13,000	12	182	−58.7		10	180	−61.5		14	177	−61.7	
14,000	12	155	−63.3		11	153	−64.6		14	151	−61.8	
15,000	12	132	−66.8		11	130	−66.9		14	128	−61.5	
16,000	10	112	−68.7		11	110	−68.8		13	110	−62.2	
17,000	10	95	−68.3		11	93	−68.2		12	93	−62.4	
18,000	9	80	−64.9		9	79	−66.5		10	79	−60.7	
19,000	8	68	−61.3		7	67	−63.1		7	67	−57.8	
20,000					5	57	−59.4		5	57	−55.8	
21,000												

Altitude (meters) m. s. l.	Bismarck, N. Dak. (505 m.)				Boise, Idaho (864 m.)				Buffalo, N. Y. (220 m.)				Charleston, S. C. (14 m.)			
	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.
Surface	13	959	18.6	64	13	915	22.8	37	12	994	14.0	87	13	1,018	22.2	91
500									12	962	15.4	70	13	963	21.2	73
1,000	13	906	21.5	48	13	901	25.7	33	12	906	12.8	69	13	909	19.3	68
1,500	13	855	18.1	49	13	852	24.8	28	12	853	9.3	73	13	857	16.8	63
2,000	13	806	14.5	54	13	803	21.4	27	12	803	6.1	78	13	808	14.4	66
2,500	13	759	11.5	56	13	758	17.2	28	12	755	3.1	71	13	762	11.6	75
3,000	13	715	8.5	54	13	714	13.3	29	12	710	0.9	60	13	717	8.3	74
4,000	13	633	2.2	54	13	634	5.6	36	12	626	−4.8	52	13	635	2.8	71
5,000	13	558	−4.3	50	12	560	−2.8	43	12	551	−11.0	43	13	561	−2.6	67
6,000	13	491	−10.4	42	12	493	−9.9	43	12	483	−17.6	33	13	494	−8.1	67
7,000	13	431	−17.6	41	12	432	−16.9	40	12	422	−25.2	33	13	434	−14.1	67
8,000	13	376	−25.2	43	12	377	−24.9	40	12	367	−32.5	31	13	379	−20.8	67
9,000	13	326	−32.9	39	12	328	−33.1	39	12	318	−39.0	34	13	330	−28.4	67
10,000	13	282	−41.2		12	284	−41.0		12	274	−44.5		13	286	−36.4	65
11,000	13	243	−49.1		12	244	−49.2		12	236	−48.9		13	247	−44.8	
12,000	12	208	−56.7		12	210	−56.3		12	202	−52.3		13	213	−53.0	
13,000	12	177	−60.4		12	179	−60.3		12	173	−54.3		13	182	−60.5	
14,000	11	151	−58.2		12	152	−59.4		12	148	−54.8		12	154	−64.9	
15,000	11	129	−58.6		12	130	−60.0		11	126	−54.9		12	131	−66.7	
16,000	11	110	−59.1		11	111	−60.8		9	108	−55.7		12	111	−68.7	
17,000	10	94	−57.7		11	94	−59.9		7	92	−55.2		11	94	−67.8	
18,000	8	80	−56.5		8	80	−58.0		5	79	−54.5		11	79	−65.5	
19,000					6	68	−56.4		5	67	−53.1		9	67	−63.1	
20,000													7	58	−60.3	
21,000													6	49	−58.5	

Stations and elevations in meters above sea level

Altitude (meters) m. s. l.	Denver, Colo. (1,616 m.)				El Paso, Tex. (1,193 m.)				Ely, Nev. (1,908 m.)			
	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.
Surface	13	843	18.2	66	13	884	26.7	33	13	812	17.9	34
500												
1,000												
1,500					13	853	26.4	31				
2,000	13	806	19.4	58	13	806	23.6	32	13	804	20.4	30
2,500	13	760	16.6	54	13	761	20.0	33	13	758	20.1	25
3,000	13	716	13.2	54	13	718	16.2	37	13	715	16.4	25
4,000	13	635	6.1	60	13	637	8.1	43	13	635	8.0	31
5,000	13	562	−1.2	67	13	564	0.1	54	13	561	−0.7	38
6,000	13	494	−8.5	71	13	497	−6.3	51	13	494	−8.7	39
7,000	13	434	−15.5	71	13	437	−12.7	47	13	434	−15.8	35
8,000	13	380	−22.2	66	13	382	−19.2	45	13	380	−23.4	31
9,000	13	330	−29.8	65	13	333	−26.6	41	13	330	−31.5	30
10,000	13	287	−38.1		13	290	−34.5	38	13	286	−39.4	
11,000	11	247	−46.4		13	250	−42.4		13	246	−47.3	
12,000	11	212	−53.6		13	216	−50.3		13	211	−54.2	
13,000	11	181	−58.6		13	184	−57.4		13	180	−58.7	
14,000	10	154	−62.4		13	157	−62.8		13	154	−61.7	
15,000	9	132	−64.4		12	133	−67.8		13	131	−62.8	
16,000	9	112	−65.5		11	113	−70.8		13	111	−64.3	
17,000	9	95	−65.0		11	95	−70.6		11	94	−63.1	
18,000	9	81	−63.1		10	80	−67.7		9	80	−60.6	
19,000	7	69	−60.0		8	68	−64.6		5	68	−57.7	
20,000												
21,000												

Altitude (meters) m. s. l.	Fairbanks, Alaska (153 m.)				Joliet, Ill. (178 m.)				Juneau, Alaska (49 m.)			
	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.
Surface	13	993	21.3	45	13	999	15.8	77	13	1012	13.5	80
500	13	956	18.8	43	13	962	19.3	56	13	959	11.0	79
1,000	13	901	14.8	45	13	907	17.0	59	13	902	7.8	82
1,500	13	849	10.6	49	13	855	13.4	64	13	850	4.6	85
2,000	13	799	6.5	53	13	805	10.1	67	13	798	2.3	84
2,500	13	751	2.5	57	13	758	7.5	65	12	750	−0.6	85
3,000	13	706	−1.3	59	13	713	4.7	59	12	704	−3.4	84
4,000	13	622	−6.7	56	13	631	−0.4	50	12	620	−9.2	72
5,000	13	547	−12.6	50	13	556	−5.7	39	12	545	−15.6	64
6,000	13	479	−18.9	47	13	488	−12.5	35	12	476	−22.7	61
7,000	13	418	−26.2	47	13	428	−19.7	31	10	415	−30.5	60
8,000	13	363	−33.9	46	13	373	−27.1	30	9	360	−38.1	
9,000	13	314	−41.3		12	324	−35.0		9	311	−46.1	
10,000	13	270	−47.8		11	280	−42.4		9	266	−53.4	
11,000	13	232	−52.7		11	241	−49.5		9	228	−56.2	
12,000	13	199	−53.2		10	206	−55.3		9	195	−52.5	
13,000	13	171	−50.5		9	176	−59.0		9	167	−50.0	
14,000	13	146	−48.9		9	150	−60.3		6	144	−50.2	
15,000	13	125	−47.5		8	127	−59.4		5	123	−50.5	
16,000	12	108	−46.7		7	108	−60.0					
17,000	10	93	−46.0		7	92	−59.3					
18,000	10	80	−45.4		5	78	−57.2					
19,000	10	69	−44.8									
20,000	10	59	−44.1									
21,000	7	51	−43.6									

See footnotes at end of table.

TABLE 1.—*Mean free-air barometric pressure (P.) in millibars, temperature (T.) in degrees Centigrade, and relative humidities (R. H.) in percent, obtained by airplanes and radisondes during July 1940*—Continued

Stations and elevations in meters above sea level

Altitude (meters) m. s. l.	Lakehurst, N. J.[1] (39 m.)				Medford, Oreg. (401 m.)				Miami, Fla. (4 m.)			
	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R.
Surface	31	1,012	18.2	93	13	969	22.6	33	13	1,019	25.4	89
500	31	960	20.5	68	12	958	22.5	34	13	963	24.1	83
1,000	31	906	17.7	62	13	904	20.2	35	13	910	21.1	77
1,500	31	854	14.5	62	13	853	16.9	40	13	859	18.6	68
2,000	31	805	11.6	58	13	804	13.9	45	13	809	15.9	64
2,500	30	757	8.8	52	13	757	11.8	47	13	763	13.1	59
3,000	30	713	6.1	47	13	713	9.2	45	13	718	10.2	54
4,000	29	630	1.0	42	13	631	2.7	44	13	637	4.6	51
5,000	29	556	−4.6	42	13	557	−3.6	41	13	563	−1.9	54
6,000	29	489	−10.5	41	13	490	−10.4	36	13	496	−7.6	62
7,000	29	429	−17.0	43	13	430	−17.5	34	13	435	−13.5	61
8,000	29	375	−24.1	43	13	375	−25.4	34	13	381	−20.0	60
9,000	29	326	−31.3	41	13	326	−33.6	35	13	332	−27.4	56
10,000	29	283	−38.9		13	282	−41.7		13	288	−35.3	52
11,000	29	244	−46.2		13	242	−49.8		13	249	−43.6	
12,000	28	210	−52.8		13	208	−57.2		13	214	−51.6	
13,000	28	179	−58.1		13	177	−61.5		13	183	−58.9	
14,000	28	153	−61.5		13	151	−60.3		13	156	−64.9	
15,000	28	130	−63.2		12	129	−59.5		12	132	−68.7	
16,000	28	111	−63.0		11	110	−60.0		12	112	−70.3	
17,000	27	95	−61.5		11	93	−60.0		12	94	−70.2	
18,000	24	81	−59.5		10	80	−59.4		10	80	−67.7	
19,000	16	68	−57.2		10	68	−58.1		9	68	−64.7	
20,000	8	57	−55.0						6	57	−61.5	

Altitude (meters) m. s. l.	Minneapolis, Minn. (263 m.)				Nashville, Tenn. (180 m.)				Norfolk, Va.[1 2] (10 m.)				Oakland, Calif. (2 m.)			
	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	H. R.
Surface	13	989	18.7	71	13	907	20.4	85	27	1,019	22.5	86	13	1,015	15.8	79
500	13	961	19.5	58	13	961	19.5	80	27	964	22.9	67	13	958	18.0	71
1,000	13	907	17.2	57	13	907	17.9	77	27	910	20.0	63	13	905	22.0	35
1,500	12	855	13.3	63	13	855	15.4	78	27	858	16.5	63	13	824	20.8	26
2,000	12	805	9.8	65	13	806	12.9	75	27	809	13.4	56	13	805	18.1	24
2,500	12	758	6.6	61	13	759	10.4	73	27	762	10.8	50	13	759	14.5	23
3,000	12	713	4.2	53	13	715	7.7	73	27	717	7.8	48	13	715	11.2	22
4,000	12	630	−0.3	38	12	633	2.0	69	27	635	1.9	44	13	634	4.7	22
5,000	12	556	−6.1	37	12	558	−3.5	63	25	560	−4.0	38	13	560	−2.2	22
6,000	12	488	−12.7	37	12	492	−9.2	56					13	493	−8.8	21
7,000	12	428	−19.6	35	12	432	−15.4	54					12	433	−16.4	20
8,000	12	373	−27.5	31	12	378	−22.4	53					12	377	−24.7	20
9,000	12	324	−35.2	32	12	328	−30.8	53					12	328	−32.7	21
10,000	12	280	−42.7		12	285	−38.3						12	284	−40.7	
11,000	12	241	−50.0		12	246	−46.9						12	245	−48.7	
12,000	11	206	−56.0		12	211	−54.9						12	209	−55.6	
13,000	11	176	−59.6		12	180	−60.2						12	179	−60.2	
14,000	10	150	−58.3		11	153	−63.3						12	152	−61.7	
15,000	10	127	−58.0		11	130	−64.7						12	130	−62.2	
16,000	9	109	−58.0		10	110	−65.2						12	110	−63.1	
17,000	9	92	−57.6		10	94	−64.6						12	94	−62.8	
18,000	9	79	−57.2		8	79	−63.0						10	80	−61.7	
19,000	6	67	−55.6		8	67	−60.9						8	68	−59.9	
20,000					5	57	−57.9						6	58	−57.7	

Stations and elevations in meters above sea level

Altitude (meters) m. s. l.	Oklahoma City, Okla. (391 m.)				Omaha, Nebr. (301 m.)				Pearl Harbor, T. H.[1 2] (6 m.)			
	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.
Surface	13	972	21.1	82	13	984	22.0	57	30	1,015	23.9	82
500	13	960	21.6	77	13	962	22.4	53	30	960	21.8	82
1,000	13	906	20.1	68	13	908	20.1	53	30	906	18.5	87
1,500	13	855	17.9	60	13	856	17.1	55	30	855	16.4	76
2,000	13	806	17.0	48	13	807	14.4	56	30	806	14.3	66
2,500	13	760	15.0	41	13	760	12.6	50	30	759	13.1	45
3,000	13	716	12.3	38	13	716	9.8	46	30	716	11.0	34
4,000	13	635	5.9	37	13	634	3.9	47	30	634	4.9	32
5,000	13	561	−1.2	42	13	560	−2.3	46				
6,000	13	494	−8.7	48	12	493	−8.8	42				
7,000	13	434	−14.6	43	12	433	−15.6	40				
8,000	13	379	−22.3	41	12	378	−22.5	39				
9,000	13	330	−29.6	40	12	329	−29.9	38				
10,000	13	286	−37.7		11	285	−37.8					
11,000	13	247	−45.2		11	246	−45.8					
12,000	13	212	−52.2		11	212	−53.0					
13,000	13	181	−57.9		11	181	−57.7					
14,000	12	154	−63.0		11	154	−59.7					
15,000	12	131	−65.3		11	131	−61.6					
16,000	12	111	−66.9		11	112	−62.0					
17,000	10	94	−67.0		10	95	−61.5					
18,000	9	80	−66.3		9	81	−60.3					
19,000	8	68	−63.9		9	69	−58.9					
20,000	5	58	−60.8									
21,000												

Altitude (meters) m. s. l.	Pensacola, Fla.[1] (24 m.)				Phoenix, Ariz. (339 m.)				St. Louis, Mo. (171 m.)			
	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.
Surface	30	1,016	26.1	79	13	970	30.9	26	13	999	21.5	68
500	30	962	24.0	73	13	953	34.5	22	13	961	22.2	62
1,000	30	909	21.0	67	13	902	34.4	18	13	908	19.6	62
1,500	30	858	17.9	65	13	853	30.8	18	13	856	15.8	66
2,000	30	809	14.8	64	13	806	26.3	18	13	807	12.5	67
2,500	30	762	11.8	61	13	761	22.2	18	13	760	11.0	54
3,000	30	718	9.2	60	13	718	18.0	19	13	716	9.1	44
4,000	30	636	3.6	57	13	638	10.0	24	13	634	3.7	33
5,000	30	562	−1.9	46	13	565	2.5	25	13	560	−2.4	31
6,000	27	495	−7.3	41	13	498	−4.9	26	13	493	−9.4	31
7,000	25	434	−13.3	41	13	438	−11.8	26	13	433	−16.2	32
8,000	23	380	−20.0	51	13	384	−19.5	26	13	378	−23.5	31
9,000	23	330	−27.4	52	13	334	−27.6	25	13	328	−31.6	28
10,000	21	288	−35.0	46	13	291	−35.6	24	13	285	−39.4	
11,000	18	249	−43.0		13	251	−43.3		12	245	−47.0	
12,000	17	214	−51.0		13	216	−50.5		12	211	−54.0	
13,000	13	183	−58.2		13	185	−56.9		12	180	−57.7	
14,000	11	155	−64.7		13	158	−61.6		12	153	−60.2	
15,000	8	132	−68.3		12	134	−65.7		10	131	−61.4	
16,000	8	112	−70.4		12	114	−69.5		9	111	−61.9	
17,000	5	94	−71.0		12	96	−69.1		9	95	−61.2	
18,000					10	81	−65.7		9	80	−59.1	
19,000					8	69	−61.9		7	69	−57.2	
20,000					7	59	−59.4		6	58	−55.0	
21,000									6	50	−52.9	

Stations and elevations in meters above sea level

Altitude (meters) m. s. l.	San Antonio, Tex. (174 m.)				San Diego, Calif.[1] (19 m.)				Sault Ste. Marie, Mich. (221 m.)			
	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.
Surface	13	996	24.5	80	30	1,011	18.5	83	13	994	11.9	86
500	13	960	24.1	76	30	957	19.0	62	13	962	15.4	65
1,000	13	905	21.8	76	30	903	21.6	34	13	906	13.4	59
1,500	13	855	18.8	76	20	852	22.4	24	13	854	9.7	62
2,000	13	806	16.0	70	30	804	20.0	24	13	803	6.0	66
2,500	13	760	13.7	61	30	759	16.6	24	13	755	2.5	69
3,000	13	716	11.6	50	30	716	13.5	24	13	710	−0.5	66
4,000	12	635	5.7	46	30	633	6.4	28	13	626	−5.6	54
5,000	12	562	−1.2	47	30	560	−2.9	32	13	550	−11.3	48
6,000	11	495	−6.8	43	28	493	−9.9	34	12	483	−17.6	50
7,000	11	434	−13.3	37	28	433	−17.1	21	12	421	−25.0	47
8,000	11	380	−20.3	35	28	379	−24.6		12	366	−33.0	44
9,000	11	332	−27.6	35	28	330	−32.7		12	316	−41.0	
10,000	11	288	−35.5	34	28	286	−39.8		12	273	−47.5	
11,000	11	249	−42.9		27	246	−46.9		12	234	−51.5	
12,000	11	214	−49.7		26	212	−53.8		11	201	−54.8	
13,000	11	184	−56.1		25	181	−59.9		11	171	−54.7	
14,000	11	156	−61.9		25	154	−65.2		11	146	−54.0	
15,000	11	133	−66.7		24	130	−69.6		10	125	−54.7	
16,000	11	112	−68.6		21	110	−71.0		9	107	−55.8	
17,000	10	95	−69.1		18	94	−69.5		5	91	−54.9	
18,000	10	80	−65.9		16	80	−67.3					
19,000	8	68	−63.7		12	68	−65.3					
20,000	8	58	−60.5		7	56	−63.2					

Altitude (meters) m. s. l.	Seattle, Wash.[1] (27 m.)				St. Thomas, V. I.[1 2] (8 m.)				Spokane, Wash. (598 m.)				Washington, D. C.[1] (7 m.)			
	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.
Surface	20	1,013	17.5	73	30	1,018	28.0	79	11	944	22.2	34	30	1,017	20.4	85
500	20	958	15.7	67	30	963	23.0	95					30	961	20.4	66
1,000	20	904	13.0	66	30	910	19.7	90	11	902	24.3	30	30	906	18.1	62
1,500	20	851	10.0	67	30	858	16.4	85	11	852	20.7	28	30	855	15.0	63
2,000	20	801	7.7	64	30	809	14.9	72	11	803	16.5	29	30	805	12.0	60
2,500	20	754	5.0	60	30	762	13.1	58	11	757	12.7	31	30	758	9.5	54
3,000	20	709	2.5	55	30	718	10.3	50	11	713	8.4	34	30	714	6.9	50
4,000	20	626	−3.4	48	30	636	4.3	49	11	630	1.2	39	30	631	1.7	44
5,000	19	550	−9.4	37					11	556	−5.7	38	30	557	−3.8	42
6,000	17	483	−15.8	41					11	480	−12.4	38	27	490	−9.6	39
7,000	16	422	−23.4	44					11	428	−19.3	40	27	430	−16.0	37
8,000	15	368	−31.2	46					11	374	−26.8	41	18	376	−23.0	33
9,000	15	319	−38.8	44					11	324	−34.6	40	18	328	−30.6	34
10,000	12	276	−45.8						11	281	−42.7		17	284	−38.0	
11,000	10	237	−51.9						11	242	−50.4		16	244	−45.9	
12,000	7	203	−52.4						11	207	−56.4		12	210	−53.0	
13,000	7	174	−50.1						11	176	−57.9		11	179	−59.1	
14,000	6	150	−50.3						11	150	−55.7		7	153	−61.1	
15,000	5	129	−51.2						10	128	−55.7		7	130	−63.5	
16,000									10	110	−56.2		6	111	−63.4	
17,000									9	94	−56.0		5	94	−61.8	
18,000									9	81	−55.3					
19,000									8	69	−53.9					
20,000																

See footnotes at end of table.

TABLE 1.—*Mean free-air barometric pressure (P.) in millibars, temperature (T.) in degrees Centigrade, and relative humidities (R. H.) in percent, obtained by airplanes and radiosondes during July 1940*—Continued

Altitude (meters) m. s. l.	Atlantic Station No. 1[1][3] (5 m.) Number of obs.	P.	T.	R. H.	Atlantic Station No. 2[1][4] (5 m.) Number of obs.	P.	T.	R. H.
Surface	31	1,020	23.5	86	25	1,026	22.5	86
500	31	963	19.7	85	25	968	19.3	88
1,000	31	908	17.0	77	25	914	16.6	82
1,500	31	857	14.5	71	25	861	14.6	71
2,000	31	807	12.3	65	25	812	12.6	65
2,500	31	760	9.6	65	25	764	10.4	61
3,000	31	716	7.0	61	25	720	7.7	57
4,000	30	633	1.1	60	25	637	1.7	51
5,000	28	559	−4.2	56	25	562	−4.2	46
6,000	28	492	−9.8	51	25	494	−9.5	38
7,000	28	431	−16.1	48	24	434	−15.8	34
8,000	28	377	−23.4	47	24	379	−23.0	32
9,000	27	328	−30.5	47	23	330	−30.4	35
10,000	26	284	−37.9	47	23	286	−38.3	32
11,000	25	245	−45.0		20	247	−46.1	
12,000	24	211	−52.0		19	212	−53.5	
13,000	24	180	−57.2		18	181	−59.1	
14,000	23	154	−60.5		16	154	−61.6	
15,000	23	131	−61.2		16	131	−63.0	
16,000	22	112	−61.3		15	112	−62.2	
17,000	19	95	−60.7		13	94	−61.3	
18,000	19	81	−59.0		10	80	−59.7	
19,000	16	69	−57.4		7	69	−57.5	
20,000	11	58	−56.0		5	58	−55.8	
21,000	8	50	−54.5					

NOTE.—All observations taken at 1 a. m., 75th meridian time, except those at Washington, D. C., Lakehurst, N. J., Norfolk, Va., and Pensacola, Fla., where they are taken before 5 a. m., 75th meridian time. At Pearl Harbor, T. H., observations are taken after sunrise.

None of the means included in this table are based on less 5 standard level observations.

Number of observations refers to pressure only as temperature and humidity data are missing for some observations at certain levels; also, the humidity data are not used in daily observations when the temperature is below −40.0° C.

[1] U. S. Navy.
[2] Airplane observations.
[3] In or near the 5° square: Lat. 35°00′ N. to 40°00′ N. Long. 55°00′ W. to 60°00′ W.
[4] In or near the 5° square: Lat. 40°00′ N. to 45°00′ N. Long. 40°00′ W. to 45°00′ W.

TABLE 2.—*Free-air resultant winds based on pilot balloon observations made near 5 p. m. (75th meridian time) during July 1940. Directions given in degrees from North (N=360°, E=90°, S=180°, W=270°)—Velocities in meters per second*

Altitude (meters) m. s. l.	Abilene, Tex. (537 m.) Obs.	Dir.	Vel.	Albuquerque, N. Mex. (1,630 m.) Obs.	Dir.	Vel.	Atlanta, Ga. (299 m.) Obs.	Dir.	Vel.	Billings, Mont. (1,095 m.) Obs.	Dir.	Vel.	Bismarck, N. Dak. (512 m.) Obs.	Dir.	Vel.	Boise, Idaho (870 m.) Obs.	Dir.	Vel.	Brownsville, Tex. (7 m.) Obs.	Dir.	Vel.	Buffalo, N. Y. (220 m.) Obs.	Dir.	Vel.	Burlington, Vt. (132 m.) Obs.	Dir.	Vel.	Charleston, S. C. (18 m.) Obs.	Dir.	Vel.	Chicago, Ill. (192 m.) Obs.	Dir.	Vel.	Cincinnati, Ohio (157 m.) Obs.	Dir.	Vel.	Denver, Colo. (1,627 m.) Obs.	Dir.	Vel.
Surface	31	173	3.3	31	238	2.5	31	68	0.5	31	84	1.4	31	163	1.3	31	321	3.6	31	129	5.8	30	247	3.4	31	220	0.8	30	153	1.5	31	209	0.3	31	162	1.0	31	32	1.6
500							31	76	.8										31	141	7.1	30	259	4.6	31	267	1.7	29	162	1.5	31	297	.4	31	233	.8			
1,000	31	166	3.6				20	131	.9				31	120	1.6	31	324	4.2	30	152	5.8	30	266	5.3	31	281	3.1	28	268	.5	31	248	1.8	31	265	1.4			
1,500	31	173	3.8				26	251	1.0	31	120	1.3	31	166	1.7	31	311	2.6	28	153	4.7	30	267	5.4	30	289	5.1	23	316	1.3	30	241	3.1	30	253	2.1			
2,000	30	167	3.2	31	240	2.8	21	267	1.9	31	185	1.5	31	228	2.3	31	251	2.7	27	155	4.5	30	277	7.1	28	285	5.8	21	307	1.1	27	264	3.3	30	271	3.0	31	52	1.5
2,500	30	184	1.5	31	253	1.5	20	266	2.4	31	233	3.1	29	266	4.4	31	238	4.3	25	156	4.0	28	281	7.5	24	281	6.6	18	263	2.2	26	265	3.6	26	279	3.0	31	56	1.5
3,000	28	159	0.3	31	260	1.1	21	260	2.4	31	242	4.9	29	275	6.4	31	226	6.1	24	156	3.4	25	289	7.7	18	285	7.3	17	254	2.7	26	279	4.3	25	281	4.3	30	117	.9
4,000	28	356	1.3	30	353	2.0	19	252	2.6	27	247	8.8	24	278	9.2	30	226	8.7	22	140	3.0	22	298	10.4	13	292	6.6	12	264	3.9	21	307	6.4	18	297	3.6	28	270	1.8
5,000	26	5	3.2	26	349	3.7	14	271	3.7	24	250	12.6	21	280	12.2	30	227	11.3	19	110	2.8	20	298	12.1							19	316	9.0	16	306	4.6	25	281	4.0
6,000	26	17	2.5	23	329	2.6	13	258	3.1	24	252	15.2	17	283	15.4	28	229	13.6	16	104	2.4	16	301	11.7							13	308	9.3	13	302	6.7	17	273	3.8
8,000	22	28	3.1	19	308	4.7	11	250	1.7	17	246	18.3	12	275	18.9	26	234	17.4	12	127	1.1	10	304	10.4							11	309	12.8				10	268	7.9
10,000	22	31	3.9	15	246	2.8	10	225	3.6	10	238	22.8				21	227	22.9																					
12,000	20	38	3.0	10	352	5.3										12	227	30.3																					
14,000	11	4	1.9																																				

Altitude (meters) m. s. l.	El Paso, Tex. (1,196 m.) Obs.	Dir.	Vel.	Ely, Nev. (1,910 m.) Obs.	Dir.	Vel.	Grand Junction, Colo. (1,413 m.) Obs.	Dir.	Vel.	Greensboro, N. C. (271 m.) Obs.	Dir.	Vel.	Havre, Mont. (766 m.) Obs.	Dir.	Vel.	Jacksonville, Fla. (14 m.) Obs.	Dir.	Vel.	Las Vegas, Nev. (570 m.) Obs.	Dir.	Vel.	Little Rock, Ark. (79 m.) Obs.	Dir.	Vel.	Medford, Oreg. (410 m.) Obs.	Dir.	Vel.	Miami, Fla. (10 m.) Obs.	Dir.	Vel.	Minneapolis, Minn. (261 m.) Obs.	Dir.	Vel.	Mobile, Ala. (10 m.) Obs.	Dir.	Vel.	Nashville, Tenn. (194 m.) Obs.	Dir.	Vel.
Surface	31	151	1.9	31	202	4.8	31	324	1.1	30	27	.2	29	56	0.7	30	132	1.8	31	155	4.3	31	143	0.8	31	313	3.3	31	109	3.1	31	165	1.2	31	186	2.4	30	287	0.5
500										30	270	0.4				30	152	1.9				31	155	1.6	31	315	3.6	31	115	4.3	31	176	1.8	31	209	4.2	30	243	.4
1,000										30	231	1.5	29	57	1.5	29	218	1.7	31	175	4.6	27	183	1.1	31	314	3.1	31	110	3.8	31	201	2.5	30	218	3.7	30	218	.7
1,500	31	161	2.1				31	326	1.2	29	259	2.2	29	92	.4	27	271	2.2	31	179	4.5	25	215	1.1	30	271	2.2	30	101	3.2	30	230	3.6	28	224	3.7	29	222	1.0
2,000	30	146	1.6	31	202	4.9	31	322	1.4	26	262	2.5	29	234	1.9	27	264	2.4	31	187	5.0	24	259	.7	29	223	4.0	30	96	2.5	27	244	5.4	24	251	2.8	26	260	.9
2,500	31	117	1.2	31	201	5.8	31	277	1.4	24	291	2.8	29	243	4.8	25	254	2.0	31	198	6.1	23	3	.8	30	205	5.9	31	98	1.8	22	258	6.8	21	253	3.0	25	249	2.1
3,000	29	109	1.0	31	205	5.3	31	256	2.2	25	285	3.4	27	257	7.6	22	260	2.1	31	206	7.0	23	358	1.4	28	214	7.6	29	121	1.6	19	268	7.1	23	257	4.0	22	258	2.9
4,000	28	64	1.7	31	201	6.6	30	252	5.1	20	293	3.2	19	257	11.7	21	265	2.9	31	213	6.8	18	1	2.5	27	223	9.7	27	118	1.7	14	297	9.9	19	257	3.6	18	281	3.0
5,000	23	63	2.3	29	210	6.8	26	241	6.3	18	302	4.3	15	254	14.4	18	242	3.7	31	210	6.9	13	357	1.0	27	225	12.2	23	116	2.4	12	292	11.6	11	208	2.5	13	304	1.6
6,000	14	80	1.5	26	224	9.8	21	242	5.9	16	299	3.7				13	245	2.7	29	217	8.0				25	227	15.1	22	121	1.5	10	283	12.6						
8,000	11	83	2.6	24	228	13.3				15	264	4.4				11	71	1.6	28	214	10.0				21	231	18.9	12	135	2.4									
10,000				21	230	18.4				12	250	5.8							27	223	14.8				16	232	23.6	11	123	3.4									
12,000				16	235	20.4				12	278	4.3							24	230	18.0																		
14,000				16	228	17.7				10	327	4.4							24	229	15.8																		
16,000																			20	223	7.6																		
18,000																			11	176	4.8																		

TABLE 2.—*Free-air resultant winds based on pilot balloon observations made near 5 p. m. (75th meridian time) during July 1940. Directions given in degrees from North (N=360°, E=90°, S=180°, W=270°)—Velocities in meters per second*—Continued

Altitude (meters) m. s. l.	New York, N. Y. (15 m.) Observations	Direction	Velocity	Oakland, Calif. (8 m.) Observations	Direction	Velocity	Oklahoma City, Okla. (402 m.) Observations	Direction	Velocity	Omaha, Nebr. (306 m.) Observations	Direction	Velocity	Phoenix, Ariz. (344 m.) Observations	Direction	Velocity	Rapid City, S. Dak. (982 m.) Observations	Direction	Velocity	St. Louis, Mo. (181 m.) Observations	Direction	Velocity
Surface	31	193	1.5	31	264	5.4	31	158	5.1	31	140	2.7	31	257	1.7	31	121	3.7	31	158	1.5
500	31	242	2.2	31	271	3.4	31	159	5.9	31	141	3.5	31	262	2.0				31	148	1.1
1,000	28	276	3.7	30	261	3.6	31	173	5.7	31	160	4.6	31	254	2.6	31	123	3.6	31	171	1.6
1,500	27	290	4.7	30	240	3.3	30	191	5.1	31	188	4.9	31	237	3.0	31	146	4.0	29	162	1.0
2,000	25	302	6.4	30	235	2.7	29	207	3.0	29	205	5.4	31	226	3.2	31	162	4.0	28	206	1.1
2,500	23	305	6.0	30	222	3.5	28	235	1.8	28	229	4.5	31	213	3.6	30	198	3.8	28	282	.8
3,000	18	307	5.7	30	224	4.3	27	307	.8	27	261	4.3	31	215	3.0	28	241	3.9	27	319	1.8
4,000	13	303	6.6	30	227	6.4	28	347	2.5	26	287	5.3	29	194	2.8	26	252	7.2	26	337	3.6
5,000	11	300	6.6	30	223	8.0	28	357	4.3	23	312	6.0	29	174	4.4	26	250	10.1	24	333	4.9
6,000				29	220	9.9	25	352	5.1	18	311	6.8	25	193	3.3	22	264	13.7	22	318	7.0
8,000				27	222	13.2	24	2	2.7	15	302	8.9	19	265	2.6	10	266	16.9	19	312	7.5
10,000				24	219	16.6	22	16	3.6	14	314	11.0	17	239	6.7				14	318	4.9
12,000				19	223	18.0	20	36	2.6	14	312	8.8	14	250	9.9						
14,000				17	228	18.6	15	283	3.0	13	313	8.3	11	267	6.7						
16,000				13	212	10.2				12	296	6.0									

Altitude (meters) m. s. l.	San Antonio, Tex. (183 m.) Observations	Direction	Velocity	San Diego, Calif. (15 m.) Observations	Direction	Velocity	Sault Ste. Marie, Mich. (230 m.) Observations	Direction	Velocity	Seattle, Wash. (14 m.) Observations	Direction	Velocity	Spokane, Wash. (603 m.) Observations	Direction	Velocity	Washington, D. C. (10 m.) Observations	Direction	Velocity
Surface	31	124	2.6	31	294	3.8	31	287	2.9	31	233	1.9	31	212	2.6	30	234	1.2
500	31	131	3.6	31	296	3.4	31	285	4.9	31	233	2.0				30	269	1.8
1,000	31	135	3.5	31	270	1.4	31	273	5.4	28	225	2.8	31	223	3.5	30	287	2.6
1,500	31	148	3.3	30	273	2.4	30	285	5.4	27	215	3.4	30	224	3.6	30	294	3.4
2,000	30	162	2.6	30	259	3.2	28	292	5.2	26	212	4.0	30	222	4.3	30	297	4.3
2,500	29	153	2.1	29	243	3.6	27	292	6.1	23	202	4.7	28	217	5.0	29	299	5.3
3,000	27	133	.8	28	239	3.4	26	292	7.4	20	202	5.9	26	216	5.9	26	299	5.3
4,000	24	55	1.5	27	219	5.2	23	295	11.7	19	209	9.1	23	221	10.2	22	296	6.3
5,000	16	38	.9	26	196	6.2	20	307	12.8	16	216	11.1	21	222	11.7	18	289	5.6
6,000	13	33	1.3	26	209	5.4	18	307	13.4	12	225	15.4	18	232	14.1	17	275	6.3
8,000	10	25	2.7				13	317	15.5				15	230	15.8	11	280	9.9
10,000													11	234	17.0			
12,000																		
14,000																		
16,000																		

TABLE 3.—*Maximum free air wind velocities (m. p. s.), for different sections of the United States, based on pilot-balloon observations during July 1940*

Section	Surface to 2,500 meters (m. s. l.) Maximum velocity	Direction	Altitude (m.) m. s. l.	Date	Station	Between 2,500 and 5,000 meters (m. s. l.) Maximum velocity	Direction	Altitude (m.) m. s. l.	Date	Station	Above 5,000 meters (m. s. l.) Maximum velocity	Direction	Altitude (m.) m. s. l.	Date	Station
Northeast [1]	24.3	WSW	830	25	Buffalo, N. Y.	30.8	WNW	3,590	1	Columbus, Ohio	54.2	WSW	9,290	13	Caribou, Maine.
East-Central [2]	22.9	W	2,500	1	Norfolk, Va.	35.3	WNW	4,110	1	Elkins, W. Va.	65.2	WSW	9,860	4	Washington, D. C.
Southeast [3]	19.9	ESE	910	5	Atlanta, Ga.	22.7	ENE	4,250	12	Tallahassee, Fla.	43.0	SSW	10,150	18	Atlanta, Ga.
North-Central [4]	33.4	WSW	1,255	24	Minneapolis, Minn.	51.4	SW	4,600	6	Alpena, Mich.	52.0	NW	7,680	1	Milwaukee, Wis.
Central [5]	31.4	WSW	1,690	25	Sioux City, Iowa	35.8	WNW	4,600	1	Chicago, Ill.	44.8	WNW	9,760	2	Chicago, Ill.
South-Central [6]	27.8	SSE	1,190	17	Big Spring, Tex.	23.3	SE	2,630	16	Amarillo, Tex.	36.2	NE	10,540	18	Lake Charles, La.
Northwest [7]	32.4	WSW	2,350	5	Pocatello, Idaho	34.4	W	4,560	6	Pocatello, Idaho	52.5	WSW	9,460	27	Boise, Idaho.
West-Central [8]	36.7	SSW	2,277	12	Modena, Utah	61.8	WNW	3,330	6	Casper, Wyo.	64.9	WSW	9,780	24	Redding, Calif.
Southwest [9]	27.2	E	1,850	12	Albuquerque, N. Mex.	28.3	SW	3,350	23	San Diego, Calif.	53.3	SW	11,428	19	Las Vegas, Nev.

[1] Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, and northern Ohio.
[2] Delaware, Maryland, Virginia, West Virginia, southern Ohio, Kentucky, eastern Tennessee, and North Carolina.
[3] South Carolina, Georgia, Florida, and Alabama.
[4] Michigan, Wisconsin, Minnesota, North Dakota, and South Dakota.
[5] Indiana, Illinois, Iowa, Nebraska, Kansas, and Missouri.
[6] Mississippi, Arkansas, Louisiana, Oklahoma, Texas (except extreme west Texas), and western Tennessee.
[7] Montana, Idaho, Washington, and Oregon.
[8] Wyoming, Colorado, Utah, northern Nevada, and northern California.
[9] Southern California, southern Nevada, Arizona, New Mexico, and extreme west Texas.

TABLE 4.—*Mean altitudes and temperatures of significant points identifiable as tropopauses during July 1940, classified according to the potential temperatures (10° intervals between 290° and 409° A.) with which they are identified (based on radiosonde observiaions)*

Potential temperatures, °A.	Albuquerque, N. Mex. Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Atlanta, Ga. Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Billings, Mont. Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Bismarck, N. Dak. Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Boise, Idaho Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Buffalo, N. Y. Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Charleston, S. C. Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.
290-299																					
300-309																					
310-319																4	8.3	-41.2			
320-329	1	8.6	-31.1										2	9.9	-44.0	6	9.6	-46.0			
330-339	3	10.3	-42.0	5	11.2	-50.6	15	11.9	-58.7	12	11.2	-52.3	8	11.6	-55.8	8	11.1	-53.0			
340-349	9	12.8	-60.4	13	12.9	-62.0	8	12.9	-63.8	12	12.7	-61.3	12	12.7	-60.3	11	12.6	-58.4	12	12.7	-59.2
350-359	2	13.4	-63.0	2	13.4	-62.5	4	13.5	-63.0	2	13.3	-61.0	1	13.2	-61.0	4	12.8	-57.5	6	14.0	-65.8
360-369	6	14.6	-67.0	4	14.4	-66.5	2	14.3	-65.0							1	13.6	-62.0	2	14.6	-67.0
370-379	2	15.8	-70.5	2	15.2	-63.5							1	14.6	-63.0				2	15.4	-68.5
380-389	1	16.2	-69.0	5	16.7	-69.8	4	15.6	-64.2	2	15.4	-61.0	2	15.4	-62.5	4	14.4	-55.8	4	16.0	-69.5
390-399	4	16.7	-70.5	3	16.4	-68.3	2	16.2	-64.0	3	15.6	-59.7	2	15.9	-63.0				5	16.5	-69.0
400-409	1	17.0	-69.0	2	17.2	-70.0	1	16.4	-65.0	4	16.1	-59.5	2	16.2	-61.5	4	15.7	-57.8	1	17.3	-70.0
Weighted means		13.8	-61.7		14.0	-63.4		13.2	-61.8		13.0	-57.9		12.9	-58.5		12.0	-53.6		14.4	-64.7
Mean potential temperature °A. (weighted)		360.0			360.4			351.8			354.8			351.6			347.7			361.2	
No. days with observations		11			12			14			12			12			13			12	

TABLE 4.—*Mean altitudes and temperatures of significant points indentifiable as tropopauses during July 1940, classified according to the potential temperatures (10° intervals between 290° and 409° A.) with which they are identified (based on radiosonde observations)*.—Continued

Potential temperatures, °A.	Denver, Colo.			El Paso, Tex.			Ely, Nev.			Fairbanks, Alaska			Joliet, Ill.			Juneau, Alaska			Lakehurst, N. J.		
	Number of cases	Mean Altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.
290-299																					
300-309																					
310-319										5	8.5	-42.6				6	8.8	-45.3	1	7.7	-32.0
320-329							1	9.9	-42.0	8	9.9	-49.4	2	9.6	-43.5	9	10.4	-55.7	3	9.7	-47.0
330-339	6	10.9	-48.5				11	10.9	-48.3	8	11.3	-56.4	7	11.3	-52.7	3	11.2	-58.0	10	11.2	-52.9
340-349	13	12.4	-57.1	10	12.4	-55.4	15	12.3	-57.2	4	12.0	-56.5	5	12.3	-57.4				17	12.1	-54.0
350-359	3	14.1	-66.7	5	14.0	-64.0	6	13.7	-63.7	1	13.5	-62.0	5	13.4	-62.4				9	13.6	-62.7
360-369	1	14.6	-64.0	5	14.9	-68.2													9	14.8	-67.4
370-379	2	15.2	-67.0	3	16.0	-72.0	2	14.8	-64.0				1	14.3	-61.0				3	14.6	-62.0
380-389	3	15.7	-65.7	5	16.5	-72.4	4	15.7	-66.0										4	15.4	-63.8
390-399	1	16.0	-64.0	2	16.7	-72.0	4	16.1	-65.2				1	15.5	-61.0				1	16.8	-68.0
400-409	1	16.6	-65.0	1	17.4	-72.0	3	16.6	-65.0				2	16.0	-60.0				2	15.8	-59.0
Weighted means		13.1	-58.6		14.5	-64.8		13.1	-57.8		10.5	-51.8		12.5	-56.4		10.0	-52.6		12.9	-57.9
Mean potential temperature °A. (weighted)	353.7			363.7			355.8			330.5			350.2			322.2			352.7		
Number days with observations	10			12			13			13			10			9			28		

Potential temperatures, °A.	Medford, Oreg.			Miami, Fla.			Minneapolis, Minn.			Nashville, Tenn.			Oakland, Calif.			Oklahoma City, Okla.			Omaha, Nebr.		
	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.
290-299																					
300-309																					
310-319																					
320-329							3	9.1	-38.3				2	8.9	-35.5						
330-339	12	11.3	-53.5	3	11.4	-51.3	9	10.9	-50.4	3	12.0	-59.3	9	11.2	-51.2	4	10.7	-46.2	5	11.4	-53.8
340-349	16	12.6	-60.4	10	12.6	-57.6	9	12.6	-59.4	7	12.5	-58.7	11	12.4	-58.6	10	13.3	-59.2	8	12.3	-55.5
350-359	3	13.1	-61.0	9	14.0	-65.1	5	13.2	-60.4	4	13.5	-62.0	8	13.5	-62.8	7	14.0	-65.6	5	13.2	-59.0
360-369	1	14.0	-64.0	5	14.9	-68.4				2	14.2	-66.0	1	14.2	-62.0	8	14.4	-64.4	2	15.0	-68.0
370-379				3	15.7	-71.0				1	15.4	-66.0	2	14.8	-61.5	1	15.7	-71.0	1	15.1	-62.0
380-389				5	16.5	-73.4				3	15.3	-64.0	3	15.6	-65.0	4	15.9	-67.8	1	15.4	-62.0
390-399	1	16.0	-64.0	2	16.6	-70.0	1	15.3	-61.0	2	16.3	-67.5	2	15.2	-64.0	1	17.2	-73.0	3	16.0	-63.0
400-409	1	16.3	-62.0	1	17.0	-66.0	1	15.9	-60.0	2	17.2	-67.5				1	16.6	-65.0	2	16.6	-62.0
Weighted means		12.5	-58.3		14.4	-64.3		12.0	-54.5		13.9	-62.4		12.7	-57.6		13.6	-60.3		13.5	-58.6
Mean potential temperature °A (weighted)	345.3			361.1			344.6			361.2			351.1			357.5			359.4		
Number days with observations	13			12			11			11			12			13			11		

Potential temperatures, °A.	Phoenix, Ariz.			Portland, Maine			St. Louis, Mo.			San Antonio, Tex.			San Diego, Calif.			Sault Ste. Marie, Mich.			Seattle, Wash.		
	Number of cases	Mean Altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.
290-299																					
300-309																					
310-319				4	9.0	-48.8										3	9.4	-50.3			
320-329				6	9.9	-47.5	1	9.8	-43.0				4	10.2	-47.0	5	10.1	-51.0	4	9.4	-44.0
330-339	3	10.4	-39.7	10	11.5	-56.2	9	10.6	-45.6	5	10.2	-39.8	7	10.1	-38.4	8	11.5	-57.4	7	11.0	-52.9
340-349	14	12.1	-51.9	4	12.7	-63.0	10	12.3	-55.0	11	11.4	-46.5	13	12.3	-55.2	3	12.7	-60.7	3	11.9	-53.7
350-359	6	13.5	-59.5	1	13.5	-65.0	5	13.4	-60.0	7	13.4	-58.7	7	13.2	-58.7	1	13.6	-61.0			
360-369	4	14.4	-64.2				3	13.9	-61.7	8	14.8	-67.2	8	14.9	-68.9						
370-379	3	15.3	-67.3				2	15.0	-64.0	8	15.5	-68.8	6	15.6	-69.5						
380-389	11	16.3	-70.7	1	14.2	-56.0	2	15.0	-60.0	4	16.3	-70.8	5	15.9	-69.2	1	15.1	-60.0			
390-399	1	16.9	-72.0	4	15.1	-57.0	2	16.2	-64.5	2	16.8	-68.5	3	16.5	-68.7						
400-409				1	16.0	-59.0	1	16.7	-63.0	2	17.2	-68.5				1	15.5	-57.0			
Weighted means		13.9	-59.8		11.8	-54.9		12.7	-55.1		13.7	-58.8		13.3	-58.6		11.5	-55.7		10.7	-50.5
Mean potential temperature °A. (weighted)	361.2			344.2			353.7			361.8			356.2			337.8			333.4		
No days with observations	12			12			12			11			23			12			8		

Potential temperatures °A.	Spokane, Wash.			Washington, D. C.			Atlantic Station No. 1[1]			Atlantic Station No. 2[2]		
	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.
290-299												
300-309												
310-319							1	8.2	-37.0			
320-329	1	9.7	-45.0							1	9.8	-41.0
330-339	11	11.1	-51.5	3	11.3	-53.3	10	10.8	-48.4	7	11.3	-52.0
340-349	12	12.4	-59.0	5	12.6	-58.4	18	12.5	-57.9	13	12.5	-57.0
350-359	1	13.0	-60.0	3	13.4	-61.0	10	13.6	-61.5	11	13.6	-62.0
360-369				1	14.6	-64.0	3	14.2	-60.7	6	14.6	-66.2
370-379							2	14.6	-58.5	3	15.2	-65.7
380-389				2	15.7	-65.5	2	14.6	-56.0	2	15.9	-68.5
390-399	1	15.1	-57.0				2	16.0	-63.0	3	16.0	-66.0
400-409	3	15.8	-57.7				2	16.6	-64.5			
Weighted means		12.3	-55.5		13.1	-59.3		12.9	-56.9		13.4	-59.9
Mean potential temperature °A, (weighted)	347.7			352.0			352.8			354.7		
No days with observations	11			8			21			18		

[1] In or near the 5° square: Lat. 35°00′ N. to 40°00′ N. Long. 55°00′ W. to 60°00′ W.

[2] In or near the 5° square: Lat. 40°00′ N. to 45°00′ N. Long. 40°00′ W. to 45°00′ W.

WEATHER ON THE NORTH ATLANTIC OCEAN

By H. C. HUNTER

Atmospheric pressure.—The pressure exceeded normal over most parts of the North Atlantic Ocean that are covered by reports at hand. In the vicinity of the fortieth parallel of latitude, on both west and east sides of the ocean, the excess over the average pressure was considerable.

The extremes of pressure in available vessel reports were 1036.9 and 997.8 millibars (30.62 and 29.46 inches). The highest was noted on the United States Coast Guard cutter *Duane*, during the evening of the 3d, near 41° N., 44° W. The low reading was taken on the Icelandic steamer *Dettifoss*, very late on the 23d, near 55° N., 41° W.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure (sea level) at selected stations for the North Atlantic Ocean and its shores, July 1940*

Station	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Millibars	*Millibars*	*Millibars*		*Millibars*	
Lisbon, Portugal	1,020.8	+4.2	1,026	8, 12	1,014	5
Horta, Azores	1,027.0	+1.9	1,034	12	1,012	31
Belle Isle, Newfoundland[1]	1,012.7	+0.5	1,023	4	1,002	27
Halifax, Nova Scotia	1,017.2	+3.0	1,025	14, 18	1,003	31
Nantucket	1,017.3	+2.1	1,027	6	1,006	31
Hatteras	1,018.3	+2.0	1,026	6	1,011	25
Turks Island	1,017.7	−0.6	1,020	10, 13, 14	1,015	31
Key West	1,017.3	+0.4	1,021	10	1,014	3
New Orleans	1,017.3	+1.4	1,022	14	1,012	3

[1] For 24 days.

NOTE.—All data based on available observations, departures compiled from best available normals related to time of observation, except Hatteras, Key West, Nantucket, and New Orleans, which are 24-hour corrected means.

Cyclones and gales.—The month was quieter over the North Atlantic than even a summer month is likely to be. No LOW from the Tropics affected the weather appreciably, and but one instance of a gale of force exceeding 8 has been reported. The cutter *Hamilton*, during the forenoon of the 7th, experienced force 10 (whole gale) near 39° N., 60° W. At the time there was a large area of low pressure covering much of the northwestern part of the North Atlantic and eastern British North America; from this area a trough extended southward to about latitude 40° N., and thence southwestward to the vicinity of the Carolina coast. Apparently a small LOW formed within this trough and moved toward the north-northeast, the center passing not far from the *Hamilton*.

Fog.—From the Virginia capes to southwestern Nova Scotia considerable fog was reported, though in general a little less than had occurred during June. Very much more fog was noted here from the 18th to the end of July than during the first 17 days of the month. In the 5° square, 40° to 45° N., 65° to 70° W., fog occurred during 14 days, a number greater than that indicated by reports at hand for any other North Atlantic square. This square, however, is shown by records of past years to average over 20 July days with fog.

From the sixty-fifth meridian to the forty-fifth such reports as have been received indicate some fog between the fortieth and forty-fifth parallels of latitude. The square 40° to 45° N., 50° to 55° W., furnished reports of fog on 7 days, well distributed through the month.

No fog is indicated over any North Atlantic waters south of 35° latitude and almost none over waters east of 45° west longitude.

OCEAN GALES AND STORMS, JULY 1940

Vessel	Voyage: From—	Voyage: To—	Postiton at time of lowest barometer: Latitude	Postiton at time of lowest barometer: Longitude	Gale began July	Time of lowest barometer July	Gale ended July	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
NORTH ATLANTIC OCEAN			° ′	° ′				*Millibars*					
Gulfhawk, Am. M. S.	Las Piedras	Philadelphia	14 35 N.	72 15 W.	[1] 29	4p, 1	2	1,016.6	E	E, 6	ESE	E, 7	
American Legion, U. S. A. T.	Cristobal	San Juan	12 30 N.	76 00 W.	2	3a, 2	3	1,005.8	ENE	NE, 5	ENE	ENE, 7	
Hamilton, U. S. C. G.	On Station No. 1.	Out from Norfolk.	38 48 N.	59 30 W.	7	9a, 7	7	1,006.4	NE	NE, 10	WSW	NE, 10	NE-ENE-WSW.
Duane, U. S. C. G.	Station No. 2	Norfolk	39 06 N.	58 30 W.	8	2a, 8	8	1,006.4	SW	NNE, 8	NW	NNE, 8	SW-NNE-NW.
Excalibur, Am. S. S.	Lisbon	New York	40 18 N.	58 18 W.	8	8p, 8	8	1,006.4		W, 8		W, 8	S-W.
Cacique, Am. S. S.	New York	Barranquilla	[2] 11 38 N.	74 53 W.	9	12m, 10	10	1,009.8	E	E, 7	E	E, 7	
West Ira, Am. S. S.	Cristobal	San Juan	12 23 N.	73 40 W.	17	8p, 18	18	1,007.5	NE	ENE, 6	ENE	ENE, 7	
Exeter, Am. S. S.	Lisbon	New York	42 30 N.	47 12 W.	20	3a, 20	20	1,010.5		SW, 8		SW, 8	SW-N.
Trenton, U. S. S.	Ponta Delgada,	Annapolis	39 54 N.	52 00 W.	20	9a, 21	20	[3] 1,012.5	WSW	NNW, 2	WSW	SW, 8	WSW-N.
Ingham, U. S. C. G.	On Station No. 2.	Out from Boston.	40 30 N.	44 00 W.	22	3a, 23	22	1,007.8	SSW	WSW, 6		SSW, 8	SSW-WNW.
NORTH PACIFIC OCEAN													
Manoa, Am. S. S.	Los Angeles	Balboa	15 00 N.	94 54 W.	4	4a, 4	4	1,007.8	NNE	NE, 6	ENE	E, 8	NNE-ESE.
Steel Traveler, Am. S. S.	Singapore	Honolulu	7 54 N.	141 48 E.	6	9p, 7	8	1,001.7	NW	W, 8	SW	WNW, 8	WNW-SW.
Chateau Thierry, U. S. A. T.	San Francisco	Balboa	14 00 N.	95 30 W.	9	5a, 9	9	1,011.2	NNE	N, 2	ENE	NE, 9	N-NE.
Steel Traveler, Am. S. S.	Singapore	Honolulu	[2] 14 22 N.	161 03 E.	12	4a, 13	13	1,000.1	E	E, 6	E	E, 8	None.
Los Angeles, Am. S. S.	Nome	Los Angeles	54 36 N.	165 30 W.	19	1p, 19	19	994.6	ENE	SE, 8	SE	SE, 9	E-SE.
Shantung, Swed. M. S.	Los Angeles	Balboa	[2] 19 28 N.	105 19 W.	21	4a, 21	21	1,006.6	E	E, 2	SE	SE, 10	E-SE.
Niel Maersk, Dan. M. S.	do	do	17 42 N.	103 42 W.	20	5a, 21	21	1,009.8		E, 7	SE	E, 7	
Onomea, Am. S. S.	do	do	21 06 N.	107 30 W.	21	4p, 21	22	1,007.5	SE	SE, 3	SE	SE, 7	None.
Agwidale, Am. S. S.	Honolulu	do	19 55 N.	127 40 W.	29	11p, 29	30	[3] 1,001.7	NNE	ENE, 10	E	ENE, 10	NNE-ENE.
Liberator, Am. S. S.	do	do	19 36 N.	128 30 W.	29	3a, 30	30	999.5	NNE	E, 7	SSE	SE, 10	NNE-SE.
Massmar, Am. S. S.	Balboa	Los Angeles	11 30 N.	88 36 W.	30	7p, 30	30	1,010.2	NE	NE, 4	NE	NE, 7	

[1] June. [2] Postion approximate. [3] Barometer uncorrected.

WEATHER ON THE NORTH PACIFIC OCEAN

By WILLIS E. HURD

Atmospheric pressure.—Barometric conditions were practically normal over the North Pacific Ocean during July. The only considerable local departure was at Titijima, in the Ogasawara Islands, where the average pressure, 1,014.3 millibars (29.95 inches) was 3.7 millibars (0.10 inch) above the normal of the month.

Most central and northeastern waters of the ocean were almost completely dominated by an area of high pressure which extended westward unusually far into east longitude.

A shallow depression—the Aleutian LOW—lay over Bering Sea, with average pressure of 1,008.6 millibars (29.78 inches) at Petropavlovsk. In the extreme southwestern part of the ocean, the Asiatic LOW extended seaward over the southern Archipelagos of Japan, Naha, Nansei Islands, having an average barometer of 1,006.1 millibars (29.71 inches), which is slightly lower than the normal for July.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, North Pacific Ocean July 1940, at selected stations*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Millibars	*Millibars*	*Millibars*		*Millibars*	
Point Barrow	1,014.1	+0.9	1,025	15	990	16
Dutch Harbor	1,012.5	−1.3	1,028	27, 28	990	19
St. Paul	1,009.6	−.9	1,028	27	989	20
Kodiak	1,015.4	+1.5	1,030	14	1,002	17
Juneau	1,015.9	−1.7	1,027	4	1,005	27
Tatoosh Island	1,018.3	+.7	1,029	2	1,008	26
San Francisco	1,015.2	+1.0	1,021	12	1,009	26
Mazatlan	1,011.7	+.5	1,017	30	1,007	2
Honolulu	1,015.9	−.7	1,020	10	1,012	29
Midway Island	1,021.3	+1.7	1,025	7, 13, 14	1,017	20, 28
Guam	1,010.0	−.5	1,014	10	1,004	8
Manila	1,007.3	+.2	1,011	21	1,002	6
Hong Kong	1,002.7	−1.4	1,009	24	993	8
Naha	1,006.1	−.3	1,015	23, 24	967	12
Titijima	1,014.3	+3.5	1,017	8, 19, 20, 22	1,003	6
Petropavlovsk	1,008.6	−1.6	1,019	26, 30	995	12

NOTE.—Data based on 1 daily observation only, except those for Juneau, Tatoosh Island, San Francisco, and Honolulu, which are based on 2 observations. Departures are computed from best available normals related to time of observations.

Extratropical cyclones and gales.—July was one of the quietest months on record, so far as extratropical cyclones are concerned, on upper waters of the North Pacific. Several low-pressure areas formed over or entered the northern part of the ocean, but they caused few high winds. The only gale of record arising from any of these disturbances was a southeast wind of force 9 reported by the American steamer *Los Angeles* near 55° N., 165° W., on the 19th. The deepest northern cyclone of the month was then centered over the Aleutians, with lowest pressure, 989 millibars (29.20 inches), occurring at St. Paul Island on the 20th.

Typhoons and other tropical cyclones.—On page 196 is an account by Rev. Bernard F. Doucette, S. J., Weather Bureau, Manila, P. I., of one depression and five typhoons that occurred during the month in the Far East. In at least two of these typhoons, those of July 6–16 and July 25–29, there were reports of hurricane velocities.

In the southeastern Pacific there were at least two tropical cyclones, in addition to suspiciously squally conditions on 2 days south of the Gulf of Tehuantepec. In these, the American steamer *Manoa* had an east gale of force 8, with slightly depressed barometer, near 15° N., 95° W., during a thunderstorm on the 4th. On the 9th, a little to the southwestward, the United States Army transport *Chateau Thierry* had an early morning gale of force 9 from the northeast.

The earlier of the two known cyclones appeared as a depression at some distance southwest of Acapulco, Mexico, on the 20th. On the 21st a few vessels experienced rough weather off the coast between Acapulco and Manzanillo, but the only gale of any severity reported was of force 10 from the southeast, encountered by the Swedish motorship *Shantung* close to 19° N., 105° W., at 8 a. m. Four hours earlier the ship's lowest barometer was read as 1,006.6 millibars (29.72 inches), wind east, force 2. On the 24th an unknown vessel reported a northeast wind of force 8, barometer 1,009 millibars (29.80 inches), near 24° N., 125° W. Thereafter the disturbance seems to have rapidly disintegrated.

The second cyclone is known through the reports of two American steamers, the *Agwidale* on the 29th, and the *Liberator* on the 30th. The *Agwidale*, Honolulu toward Balboa, encountered the highest wind, east-northeast, force 10, at 11 p. m. of the 29th, in 19°55′ N., 127°40′ W., with uncorrected barometer down to 1,001.7 millibars (29.58 inches). The *Liberator*, on the same route, had an extreme velocity of force 10 from the southeast near 7 a. m. of the 30th. At 3 a. m., in 19°36′ N., 128°30′ W., occurred the vessel's lowest barometer, 969.5 millibars (28.63 inches). The cyclone is thus seen to have been of marked intensity and to have been traveling in a west-northwest or northwest direction.

Fog.—Numerous occurrences of fog were observed from ships along the greater extent of the northern routes between the fortieth and fiftieth parallels. Between about longitudes 150° W. and 150° E., fog was reported on some 15 to 25 percent of the days, and was in some areas long-continued and dense. The most widely fogged periods were the 7th–8th and the 15th to 18th. Along the American coast the Swiftsure Bank Lightship, at the entrance to the Strait of Juan de Fuca, reported fog on 13 days. Off Oregon there were 3 days with fog in ship reports; off California, 11 days; and off Lower California, 7 days.

TYPHOONS AND DEPRESSIONS OVER THE FAR EAST

By BERNARD F. DOUCETTE, S. J.

[Weather Bureau, Manila, P. I.]

Depression, June 26–July 3, 1940.—A depression, apparently of mild intensity, formed a short distance east of Samar, moved west-northwest across the Visayan Islands, and inclined to the north when over the China Sea. It recurved to the northeast when the center reached the western part of the Balintang Channel, a course which brought the depression to the locality of southern Formosa (Taiwan). On July 1, the direction again became west-northwest and in 2 days the center reached the continent where it disappeared.

Typhoon, July 2–9, 1940.—This storm appeared about 150 miles south-southeast of Yap on July 3, moved in a northwesterly direction to the eastern part of the Balintang Channel where it inclined to the north, moving in this direction for only a day (July 6). A northwesterly course was followed July 7 and 8, and a shift to the west took place after the center crossed Formosa. No trace of the typhoon could be found July 9.

Of all the observations received during these days, the pressure at Ishigakijima, Nansei (Loochoo) Islands, was the lowest, namely, a value of 739.7 mm. (986.2 mb.) reported July 7 at 2 p. m.

Typhoon, July 6–16, 1940.—A well-developed typhoon appeared about 300 miles south of Guam, July 6, moved northwest, then west-northwest, and inclined to the north when the center reached the ocean regions about 500 miles east of northern Luzon. This northerly course soon became north-northwest, and the storm moved into the Eastern Sea, passing about 60 miles west of Naha, Nansei (Loochoo) Islands. Recurvature took place over the central part of the Eastern Sea and the center soon reached the Sea of Japan on its way to the northern Pacific Ocean.

The steamship *Coldbrook* experienced the strength of this typhoon and sent many observations to Manila on July 11 as the center passed close to and east of the ship. Of these observations, that with the lowest pressure was made at 0400 GMT (noon, Manila time), latitude 21.6° N., longitude 128.5° E., 959.0 mb. (719.3 mm.) with west-northwest winds of force 12.

The upper winds during the period of the three storms just described showed their greatest activity over the Philippines, Indochina, and Thailand from July 4 to 13 approximately. The depression late in June was a manifestation of a quiet advance of the southwesterly current from Thailand and Indochina (and very likely from the Straits Settlements, but only scattered observations are at hand at the present writing) to the Philippines and the Pacific. The approach of the typhoon, July 2 to 9, intensified this current over Cebu, Manila, Dagupan, and Aparri, velocities of 100 k. p. h. and over being reported a few times. Zamboanga, however, did not seem to feel the effect of this strength, the velocities reaching 50 k. p. h. only infrequently. The typhoon, July 6 to 16, maintained these high velocities until about July 12 or 13, after which they diminished gradually as the storm center reached the Eastern Sea. There was no special activity in the east quadrant current at Guam during these days, as far as can be ascertained from available observations.

Typhoon, July 12–25, 1940.—This storm center moved northwesterly from the ocean regions far to the south-southeast of Guam to the latitude of southern Formosa where it changed to the west. It recurved to the northeast when within 100 miles of Formosa, but followed a northerly course into the Eastern Sea. Korea (Chosen) was crossed and the typhoon rapidly moved northeast over the Sea of Japan and beyond.

Until this typhoon reached the locality of Formosa and the Eastern Sea, it did not manifest the power that it seemed to have when it passed west of Guam. Observations from Ishigakijima, Nansei (Loochoo) Islands, showed that the center was deep, but exerting its influence only nearby and not at a distance. The 2 p. m. observation of July 21, from this island station had 739.0 mm. (985.3 mb.) with east-southeast winds, force 8, as the center moved northerly along a course about 60 miles west of the station.

Typhoon, July 25–29, 1940.—Forming about 500 miles east-northeast of San Bernardino Strait, this typhoon moved in a west-northwesterly direction, and crossed Balintang Channel and the northern part of the China Sea on its way to the continent. It passed over the coast line between Hong Kong and Swatow and disappeared over the interior on July 29.

The steamship *Kujawa Maru* reported from latitude 18°20′ N., longitude 124°30′ E., a pressure of 695 mm. (926.6 mb.) with north-northeast winds of force 12, July 26, at noon. As the typhoon crossed Balintang Channel, neither Basco nor Aparri had any extremely low pressures or strong winds, indicating that the storm had weakened or was small in area.

Typhoon, July 29–August 4, 1940.—For some time before July 29, there was a low-pressure area east of the Philippines but no definite center appeared until July 29, when it was certain that a typhoon was in existence about 600 miles east of Basco. This center moved northwest, passed about 60 miles southwest of Naha and later about 60 miles northeast of Shanghai, moving in a northerly direction almost parallel to the coast line. It crossed Shantung Peninsula on August 2, but there seemed to be traces of the circulation over northern China and Manchuria on August 4.

Observations from the steamship *Hybert* indicated the existence and movement of this storm, July 29 and 30. From latitude 24°0′ N., longitude 128°0′ E., the value of 994 mb. (745.5 mm.) with west winds, force 9, was reported (July 30, 6 a. m. Manila time), this being the lowest pressure value in the series of observations from this vessel. Naha, Nansei (Loochoo) Islands, on July 30, 2 p. m. reported pressure at 743.0 mm. (990.6 mb.) with east-northeast winds, force 5. The next day at 6 a. m., the steamship *City of Norfolk*, position in latitude 28°12′ N., longitude 125°30′ E., had pressure at 973 mb. (729.8 mm.) with east-southeast winds of force 8.

The last three typhoons of the month should be characterized as small, exerting their influence over a small area. Compared with the two in the first half of the month, very little, if any of the activity which they manifested was found after July 15. Over the Philippines, the upper winds, southwest quadrant prevailing, hardly reached values above 40 k. p. h. Usually, it might be mentioned, there was an easterly current above the southwesterly current, the high clouds showing this often and the balloons entering it a few times. Thailand and Indochina pilots showed a weaker southwesterly current during the last half of the month. Guam did not have any strong east quadrant winds, and when the southwesterly current reached that locality for a few days the velocities were always weak. This month is interesting because of these two types of typhoons, the larger during the first half, the smaller during the latter half, and moving over similar courses.

RIVER STAGES AND FLOODS

By BENNETT SWENSON

During July severe flooding was confined to the Black Warrior, Tombigbee, Pearl, and Pascagoula River Basins in the East Gulf of Mexico drainage, and the lower Colorado and Guadalupe Basins in Texas. Rcord rainfall in central and southern Texas on June 29–30, ranging from 8 to 22 inches over a small area, resulted in the floods in the Texas area which were most destructive in the upper Lavaca River. In the east Gulf area rainfall was almost continuous over a much longer period, lasting from June 29 to July 20 with only a few interruptions.

East Gulf of Mexico drainage.—Moderate flooding occurred in the lower portions of the Apalachicola River, when the stage at Blountstown, Fla., exceeded flood stage by 3.5 feet on July 14. The Choctawhatchee River just reached flood stage on the 10th at Caryville, Fla.

Rains were heavy over the Black Warrior and Tombigbee Rivers on July 2 and 3, causing sharp rises on the 3d. Heavy showers occurred over the upper parts of both basins every day except one, from the 3d to the 15th. The Black Warrior at Tuscaloosa, Ala., had three rises and the upper Tombigbee at Aberdeen and Columbus, Miss., had two, during the flood period. In the lower portions

the rise continued in the Black Warrior until the 19th, and in the Tombigbee, until the 25th.

The continuous rises, in the Tombigbee at and below Gainesville, Ala., and in the Black Warrior at and below Lock No. 7, were caused by additional heavy rains south of Columbus and Tuscaloosa. This rainfall also accounted for the high crests from Demopolis, Ala., southward. The high stage (38.6 feet) at Lock No. 1 on the Tombigbee, was due partly to late heavy rains northwest of that point and to the high water and heavy rain in the lower Alabama River Basin.

From a survey made by the United States Engineer Office the total losses from the floods in the Tombigbee and Black Warrior amounted to more than $4,000,000.

During the same period the rainfall was moderately heavy over the Alabama River watershed but was not excessive except over portions of the Cahaba and in the extreme lower portion. The only gaging station in the basin that reported above flood stage was Centerville, Ala., on the Cahaba River, where a stage of 24.2 was reached on July 16.

The following report on the floods in the Pearl and Pascagoula Rivers was prepared by the Official in Charge, Meridian, Miss.:

Floods during the month of July are very rare in the Meridian (Miss.) river district, and are usually caused by heavy rainfall attending the passage of a tropical hurricane inland over the district. The July 1940 floods were caused by almost continuous daily rainfall from June 29 to July 20, due mostly to the fact that polar air masses were moving unusually far southward for the season. The periods of rains over the district from June 29 to July 7, and from July 11 to 14, were caused by polar air masses with attendant fronts moving over the district; while for the period of July 8–10, an area of low pressure extending to high altitudes was centered over northern Mississippi, and caused daily heavy rains in most sections.

The total rainfall over the district for the 22-day period ranged from 6.35 inches at Merrill, Miss., to 17.88 inches at Shubuta, Miss. It will be noted, from an examination of table 1, that the least rainfall occurred at the southern end of the district and the heavier rainfall in the central and northern portions. As a rule, summer flood-producing storms cause heavier rainfall in the southern and central portions of the district.

TABLE 1.—*Daily rainfall in the Meridian river district for the period June 29–July 20, 1940*

Station	June		July																				
	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
Bay Springs	0.52	0.60	0.00	0.55	1.96	0.52	0.18	2.46	0.70	1.92	0.62	0.16	0.10	0.27	0.05	0.70	0.16	0.00	0.00	0.91	0.06	0.48	13.02
Collins	2.05	4.78	.00	.09	1.35	.85	.25	.46	.99	2.38	.09	.08	.90	.57	.46	.82	T	.19	.00	.00	.00	1.57	17.88
Columbia	.13	1.43	.00	.02	2.30	.32	.05	.61	2.36	.13	.85	.01	.45	.32	.00	.03	.06	.16	.04	.00	.19	1.88	11.34
D'lo	.20	1.05	.00	.00	2.00	1.60	.40	1.40	1.90	2.10	.10	T	.05	.10	T	.48	1.20	.25	.00	2.10	.30	.60	15.83
Edinburg	.83	.00	.00	.35	.87	.43	T	.53	2.27	1.50	1.29	.90	2.21	1.25	.28	T	.42	.21	.01	.06	.00	.30	13.71
Enterprise	1.23	2.41	.00	.47	2.37	.10	.28	.98	.91	.06	.09	.31	.79	.39	.39	.03	.14	.00	.19	.19	.00	.26	11.59
Franklinton	.14	.78	.00	.25	2.10	.48	.06	.39	.85	.00	.06	.66	1.05	2.36	.15	.32	.13	.02	.73	.00	.75	.72	12.00
Hattiesburg	.10	.49	.00	.21	1.10	.87	T	.07	.84	.30	.56	.92	1.20	.03	.38	2.65	T	.37	.00	.04	.14	.87	11.14
Hickory	.18	.05	.00	.75	2.12	.50	.14	1.06	1.03	.43	.45	.44	1.08	.90	.15	.04	1.04	.00	T	1.26	.00	.24	11.86
Jackson	.54	.05	.00	.04	1.07	.37	.01	2.84	1.40	.38	.02	.00	.24	.03	.35	.38	1.12	.06	.00	.16	.00	.25	9.28
Leakesville	.00	.70	.00	.00	.25	.72	.37	.25	1.70	.25	.00	.65	.25	.00	.32	1.50	.00	.00	.00	.00	.00	.90	7.86
Merrill	.04	.76	.00	.00	.60	.77	.18	.13	.54	.21	.61	.18	.17	.10	.38	1.43	.03	.08	.00	.00	.04	.00	6.35
Monticello	.30	1.83	.00	.00	1.65	1.12	.13	2.05	4.00	.00	.03	.03	1.17	.71	.00	.00	.45	1.42	.00	.01	.00	.47	15.37
Pearl River	.39	.80	.00	.30	.79	.07	.28	.10	.22	.00	.30	.93	.08	1.49	.26	.10	.06	.00	T	.54	.06	.30	7.07
Pelahatchee	1.67	.00	.00	.32	1.32	1.30	.30	1.00	2.00	1.90	.10	.60	.80	1.20	.02	.20	1.20	.33	.01	.36	.01	.60	15.24
Philadelphia	.10	.00	1.10	T	1.74	.84	T	.83	1.08	1.00	1.32	1.64	1.80	.57	T	.00	.98	.28	T	.41	.00	.51	14.20
Rio	.35	.00	.00	.11	2.41	1.02	.16	.53	1.40	.03	.51	.83	1.50	.22	.12	.00	.64	.12	.49	.00	.00	.23	10.97
Shubuta	2.71	.45	.00	.05	2.97	.70	1.25	1.35	.48	2.95	.43	.15	.58	.27	T	1.56	T	.00	.29	.10	.00	1.07	17.36
Walnut Grove	.65	.00	.00	T	1.24	.74	T	.35	1.39	1.07	.09	1.57	3.57	1.09	T	.00	.76	.30	T	1.10	.00	2.36	16.28
Waynesboro	1.87	1.26	.00	T	1.27	1.01	.57	.14	1.15	.66	.81	.04	1.16	.42	.00	.27	.19	.00	1.38	.04	.00	1.57	13.81
Meridian [1]	.51	T	.00	2.64	1.86	.84	.34	.82	.93	.05	.38	.84	1.43	.20	T	.48	1.19	T	.00	.39	.00	.98	13.88
Meridian [2]	.55	.00	1.98	1.29	.79	.18	.65	.62	.24	.02	1.34	.26	.45	T	.36	.87	.01	T	3.47	T	.74	.00	13.82
Meridian [3]	.43	T	.00	1.69	1.94	2.22	.32	.78	1.37	.05	.76	1.60	1.76	.20	.02	.25	.63	.01	1.05	.00	.42	.00	15.50
Meridian [4]	T	.00	1.84	1.99	2.17	.31	.85	1.25	.08	.77	1.60	2.00	.17	T	.24	.55	.01	.00	2.10	.00	.35	.19	16.47

[1] Meridian city office; amounts are for the 24 hours ending at 7 a. m., C. S T.
[2] Meridian airport station; amounts are for the 24 hours ending at 12:30 a. m., C. S. T.
[3] U. S. Horticultural Field Station, about 6 miles northeast of Meridian city office.
[4] U. S. Sugar Plant Field Station, about 5 miles northeast of Meridian city office. All other rainfall measurements were made at 7 a. m., C. S. T.

A study of table 2 shows that the flood stage has never been reached in July before on the Leaf River at Hattiesburg, Miss., and on the Pearl River at Monticello, Miss. The July 1940 stages were the highest of record on the Pearl River at Edinburg and Jackson, Miss., for July. On the other hand, only moderately high stages prevailed on the Chickasawhay and Pascagoula Rivers as compared to July 1916, when considerably higher stages occurred during the passage of a tropical hurricane.

TABLE 2.—*Comparison of stages in July 1940, with previous high July stages*

Station	Previous high July stage	Year	Highest stage in July 1940	Period of record
	Feet		*Feet*	
Edinburg	21.6	1934	23.7	1904–40
Jackson	24.3	1916	32.0	1901–40
Monticello	11.4	1931	21.8	1924–40
Enterprise	28.2	1916	22.3	1904–40
Shubuta	39.4	1916	31.5	1904–40
Merrill	31.0	1916	24.3	1905–40
Hattiesburg	14.3	1916	19.5	1904–40

A conservative estimate of the damage caused by these floods is approximately $500,000. Weather conditions in this section have been mostly unfavorable for agriculture during most of the year. This served to delay crops, especially truck, at least 3 or 4 weeks, and as a result, agricultural losses were unusually heavy.

Arkansas and Red Basins.—Slight local overflows occurred in the North Canadian River at Yukon, Okla., from July 2 to 6, in the Sulphur River in Texas from July 1 to 16, and in the Little River in Arkansas from July 2 to 7, but no damage of consequence was reported.

West Gulf of Mexico drainage.—Heavy rains in the upper tributaries of the Trinity River during the first week of July caused some flooding, principally in the upper basin. The overflow was not great enough to cause any damage of consequence.

The official in charge, San Antonio, Tex., reports as follows on the floods in the Colorado, Lavaca, and Guadalupe Rivers:

A slowly moving cold front attended by excessive rains crossed central and south Texas on June 29–30 and 8 to 22 inches of precipitation occurred over a strip of country 50 miles wide by 100 miles in length. It covered large sections of eight counties centered around Bastrop, Fayette, Lavaca, and De Witt. This record rainfall caused destructive floods along the lower portion of the Colorado and Guadalupe Rivers, and along the upper portion of the Lavaca River and its creek tributaries. Two persons were drowned on the Colorado River and seven lives were lost on the Lavaca River.

Rainfall over the upper watershed of the Colorado River was sufficient to cause sharp rises, but flow was reduced to about one-third by the Buchanan and Marshall Ford Dams, and no high stages occurred above Austin, Tex.

Along the lower Colorado River, La Grange, Tex., had 12 inches of rainfall during a period of 29 hours; Smithville had 20.40 inches from the afternoon of June 29 to the morning of the 30th, with 16 inches of this amount falling between 7 p. m. and 10 a. m.—a period of 15 hours. The river did not reach flood stage at Smithville, Tex., but rose to 10 to 12 feet above flood stage from Columbus to Wharton, Tex.

Along the Guadalupe River Basin, rainfall at San Marcos, Tex., measured 6.18 inches; Cuero, Tex., 14.40 inches, with 12.40 inches of this amount falling during the 24 hours ending at 7 a. m., June 30. Further downstream, Gonzales, Tex., had 5.98 inches. The river rose 10 feet above flood stage at Gonzales, and 9.5 feet above flood stage at Victoria, Tex., with the crest passing Gonzales on July 1 and Victoria on the 3d.

The upper watershed of the small Lavaca River was subjected to an excessive rainfall of unusual intensity and duration, and over parts of that section 22 inches of rainfall occurred within 36 hours, June 29–30. Hallettsville, Tex., approximately 20 miles below the headwaters of the Lavaca River, experienced the most costly flood in its history. It was here that seven persons were drowned, and property losses including crops and washed farming lands exceeded $740,000.

The Nueces River reached flood stage from July 2 to 5, inclusive, but no losses occurred.

FLOOD LOSSES FOR JULY 1940

River and drainage	Tangible property	Matured crops	Prospective crops	Livestock and other movable farm property	Suspension of business	Total
EAST GULF OF MEXICO DRAINAGE						
Apalachicola River					$4,000	$4,000
Choctawhatchee River	$3,000	$40	$300	$100	4,000	7,440
Black Warrior - Tombigbee Rivers	200,000		3,985,000		33,000	4,218,000
Pearl and Pascagoula Rivers	120,000	80,000	240,000	13,000	46,000	499,000
UPPER MISSISSIPPI BASIN						
Wisconsin River [1]	5,743	4,277	13,463		13,363	36,846
Zumbro River			5,000			5,000
WEST GULF OF MEXICO DRAINAGE						
Colorado River	76,000	66,000	8,000	2,000		152,000
Guadalupe River	60,000	95,000	16,000	8,000		179,000
Lavaca River	200,000	140,000	315,000	85,000		740,000
GULF OF CALIFORNIA DRAINAGE						
Pinal Creek (tributary of Salt River)	50,000					50,000
Tributaries of Little Colorado River	3,000	1,500		500		5,000

[1] Late in June and early in July.

FLOOD-STAGE REPORT

[All dates in July unless otherwise specified]

River and station	Flood stage	Above flood stages—dates: From—	To—	Crest: Stage	Date
EAST GULF OF MEXICO DRAINAGE	*Feet*			*Feet*	
Apalachicola: Blountstown, Fla	15	8	24	18.5	14
Choctawhatchee: Caryville, Fla	12	10	11	12.0	10–11
Cahaba: Centerville, Ala	23	15	15	24.2	15

FLOOD-STAGE REPORT—Continued

River and station	Flood stage	Above flood stages—dates: From—	To—	Crest: Stage	Date
EAST GULF OF MEXICO DRAINAGE—con.					
Black Warrior:					
Lock No. 10, Tuscaloosa, Ala	46	4 10 14	4 14 17	40.1 49.0 51.0	4 13 16
Lock No. 7, Eutaw, Ala	35	6	23	47.2	19
Tombigbee:					
Aberdeen, Miss	34	15	16	34.0	15–16
Columbus, Miss	29	5	6	30.2	5
Gainesville, Ala	36	7	25	46.7	16
Lock No. 4, Demopolis, Ala	39	6	27	56.9	20–21
Lock No. 3	33	5	30	56.9	21–22
Lock No. 2	46	7	29	58.1	22
Lock No. 1	31	7	(2)	38.6	25–27
Leaf: Hattiesburg, Miss	18	9	13	19.5	11
Chichasawhay:					
Enterprise, Miss	20	10	13	22.3	11
Shubuta, Miss	26	5	21	31.5 29.0	15 20
Pascagoula: Merrill, Miss	22	10	20	24.3	14–15
Pearl:					
Edinburg, Miss	20	9	18	23.7	13
Jackson, Miss	18	7	31	32.0	19
Monticello, Miss	15	6 19	19 31	21.8 19.5	9 22-23-24
Columbia, Miss	17	8	31	22.5 19.0	12 26
Pearl River, La	12	9	(2)	15.7	17
MISSISSIPPI SYSTEM					
Upper Mississippi Basin					
Zumbro: Theilman, Minn	35	11	11	36.7	11
Mississippi: Louisiana, Mo	12	(3)			
Missouri Basin					
Republican: Guide Rock, Nebr	9	2	2	9.1	2
Arkansas Basin					
Cimarron: Perkins, Okla	11	3	4	11.5	4
North Canadian: Yukon, Okla	8	2	6	9.2	4
Red Basin					
Ouachita: Camden, Ark	26	4	7	28.4	6
Little: Whitecliffs, Ark	25	3	7	27.1	4–5
Sulphur:					
Ringo Crossing, Tex	18	(1) 12	7 16	26.9 22.6	2 13
Naples, Tex	22	3	12	26.5	6
Lower Mississippi Basin					
Coldwater: Coldwater, Miss	13	June 29	2	14.6	June 30
WEST GULF OF MEXICO DRAINAGE					
Trinity:					
Dallas, Tex	28	2	6	32.4	4
Trinidad, Tex	28	4	16	33.4	13
Colorado:					
Columbus, Tex	24	June 30	3	36.3	1
Wharton, Tex	26	1	4	36.0	3
Guadalupe:					
Gonzales, Tex	20	June 30	2	30.0	1
Victoria, Tex	21	(1)	6	29.5	3
Nueces: Three Rivers, Tex	37	2	5	37.9	3

[1] Continued from preceding month.
[2] Continued into next month.
[3] Occasionally at or above flood stage due to operations of Dam No. 24.

CLIMATOLOGICAL DATA

[For description of tables and charts, see REVIEW, January, pp. 32 and 38]

CONDENSED CLIMATOLOGICAL SUMMARY OF TEMPERATURE AND PRECIPITATION BY SECTIONS

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Section	Temperature								Precipitation					
	Section average	Departure from the normal	Monthly extremes						Section average	Departure from the normal	Greatest monthly		Least monthly	
			Station	Highest	Date	Station	Lowest	Date			Station	Amount	Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	78.7	−1.6	Huntsville	101	28	Oneonta	54	1	8.46	+3.10	Robertsdale	23.46	Flat Rock	3.09
Arizona	80.8	+.6	3 stations	118	[1] 3	Alpine	32	25	.95	−1.23	Fresno Ranch School.	4.88	8 stations	.00
Arkansas	78.4	−2.1	2 stations	103	[1] 29	Lead Hill	48	4	4.14	+.34	Warren	14.79	Cotter	.35
California	71.6	−2.0	do	123	24	Portola	29	[1] 10	.01	−.06	China Flat	.35	242 stations	.00
Colorado	69.5	+2.3	Sedgwick	113	23	Telluride	28	3	1.66	−.51	Ordway	4.53	Holyoke	.08
Florida	81.4	+.1	Fernandina	103	25	Raiford	57	7	8.31	+1.04	Cottage Hill	20.32	Miami	1.92
Georgia	78.5	−1.5	Alapaha	106	24	4 stations	52	[1] 1	6.69	+.92	Savannah Beach	14.26	Toccoa	1.34
Idaho	69.1	+1.0	Lewiston	111	11	Pelton's Ranch	24	27	.75	+.07	Nezperce	3.11	2 stations	.00
Illinois	76.9	+.4	2 stations	107	[1] 5	Morris	41	17	1.53	−1.72	Rockford	4.56	Dwight	T
Indiana	75.9	+.2	Shoals	107	30	Frankfort	40	13	1.49	−1.85	Salamonia	4.02	Rochester	.06
Iowa	76.7	+2.0	3 stations	110	[1] 24	2 stations	42	[1] 3	4.56	+.89	Audubon	10.85	Lake Park	.52
Kansas	81.8	+2.6	do	116	25	5 stations	47	[1] 4	1.58	−1.55	Walnut	9.41	3 stations	T
Kentucky	75.5	−1.6	4 stations	102	[1] 29	3 stations	46	[1] 5	2.68	−1.48	Lynch (near)	10.87	Cold Springs	.29
Louisiana	80.9	−.9	Winnfield	102	[1] 26	2 stations	63	[1] 1	7.51	+1.35	St. Joseph	16.04	Logansport	1.13
Maryland-Delaware	75.1	−.2	Dundalk, Md	103	26	do	37	5	3.28	−1.03	Emmittsburg, Md	7.87	Odessa, Del	1.00
Michigan	69.6	+1.2	Paw Paw	104	25	do	31	[1] 1	1.91	−1.01	Ironwood	5.86	Alma	.20
Minnesota	71.7	+1.6	Canby	110	24	Meadowlands	33	2	2.68	−.58	Detroit Lakes	6.21	Windom	.19
Mississippi	78.9	−2.2	3 stations	101	[1] 28	2 stations	58	[1] 1	10.38	+5.26	Crystal Springs	19.58	Hernando	3.31
Missouri	77.7	−.3	Sikeston	111	29	do	45	[1] 4	1.58	−2.05	Lucerne	6.06	2 stations	.00
Montana	69.2	+2.1	Trout Creek (near)	107	12	Conway's Ranch	28	28	1.65	+.25	Scobey	5.01	Ballantine	.37
Nebraska	78.8	+4.3	2 stations	117	25	Mullen	41	5	1.75	−1.36	Lexington	7.26	2 stations	.15
Nevada	72.7	+.2	Overton	117	[1] 6	Owyhee	31	27	.01	−.37	Lewers Ranch	.90	26 stations	.00
New England	68.8	−.3	Brockton, Mass	98	27	Chelsea, Vt	37	14	3.61	−.11	Lake Konomoc, Conn.	7.39	Milo, Maine	1.30
New Jersey	73.9	+.1	Hammonton	104	27	2 stations	40	[1] 3	2.73	−1.96	Atlantic City	4.89	Clayton	.79
New Mexico	73.6	+1.3	2 stations	109	[1] 10	Elizabethtown	26	5	1.55	−.95	Cloudcroft	5.90	Lovington	T
New York	69.4	−.3	Utica	100	[1] 27	Whiteface Mountain	33	12	3.36	−.52	Whiteface Mountain	7.37	Oneonta	.84
North Carolina	75.9	−1.0	Albemarle	109	28	Mount Mitchell	40	6	4.26	−1.63	Jefferson	9.11	Red Springs	1.34
North Dakota	71.6	+2.6	2 stations	107	22	Edmore	37	1	3.70	+1.25	Devils Lake	7.24	Wildrose	1.18
Ohio	73.3	−.4	do	103	30	Dennison	40	5	1.93	−1.86	Newcomerstown	5.80	Fernbank	.32
Oklahoma	81.1	−.7	Alva	112	[1] 24	Buffalo	46	2	3.47	+.62	Seminole	7.87	Erick	.11
Oregon	66.3	−.2	Kingman	106	11	Fall River	25	[1] 6	.61	+.19	Spring Glade Acres	2.82	3 stations	.00
Pennsylvania	72.3	+.1	Marcus Hook	105	26	Kane Airway Station.	33	13	3.25	−1.00	Hanover	7.73	Raymond	.76
South Carolina	79.6	−.2	Bishopville	107	27	Caesars Head	53	7	3.60	−2.22	Walterboro	7.90	Effingham	1.04
South Dakota	77.6	+4.4	3 stations	116	24	Aberdeen	42	2	1.76	−.66	Ludlow	4.74	Wagner	.15
Tennessee	76.2	−1.5	Kenton	103	30	Gatlinburg	46	5	4.08	−.40	Rugby	9.13	Clarksville	.61
Texas	82.2	−.8	Memphis	112	11	Follett	46	[1] 3	1.97	−.66	Naples	7.98	7 stations	.00
Utah	73.6	+1.9	Springdale	109	6	2 stations	34	[1] 2	.38	−.53	Cedar Breaks	1.23	4 stations	.00
Virginia	74.2	−1.2	Diamond Springs	105	27	Mountain Lake	39	6	5.16	+.56	Damascus	8.47	Tappahannock	1.27
Washington	67.7	+.9	Clarkston Heights	109	11	Newport	30	4	1.18	+.53	Quinault	4.95	Wenatchee	.18
West Virginia	72.5	−.6	Martinsburg	103	26	2 stations	33	[1] 4	4.43	−.18	Gary	8.28	Winfield Locks	.98
Wisconsin	71.0	+.8	Beloit	107	23	do	33	[1] 2	2.73	−.76	Prairie du Chien	10.96	Manitowoc	.71
Wyoming	68.5	+2.8	Arcada	107	23	Buffalo Ranch	25	28	1.20	−.14	Knowles	3.64	Rock Springs	.08
Alaska (June)	54.4	+2.0	Allakaket	92	15	Barrow	10	2	1.94	+.22	Little Port Walter	9.99	Little Diomede Island.	T
Hawaii	75.6	+1.9	Mana	94	11	Haleakala	40	[1] 1	5.47	−.57	Hiloa Manawaiopuna Divide.	26.00	Puako	.00
Puerto Rico	79.2	+.8	2 stations	96	[1] 9	Guineo Reservoir	59	[1] 6	4.82	−1.29	Lares	13.72	Camuy	1.30

[1] Other dates also.

CLIMATOLOGICAL DATA FOR WEATHER BUREAU STATIONS

District and station	Elevation of instruments: Barometer above sea level	Thermometer above ground	Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Temperature of the air: Mean max.+mean min.÷2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Departure from normal	Days with 0.01 inch or more	Wind: Average hourly velocity	Prevailing direction	Maximum velocity: Miles per hour	Direction	Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F		°F	°F		°F	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
New England							**68.9**	**+0.3**										**81**	**3.55**	**+0.1**										**5.4**		
Eastport	75	67	85	29.92	30.00	+0.07	60.7	+0.3	84	31	69	46	1	52	31	57	54	83	1.67	−1.4	13	7.7	sw.	23	sw.	16	11	9	11	5.6	0.0	0.0
Greenville, Maine	1,070	6	----	28.87	30.02	----	63.4	----	88	26	77	38	14	50	41	61	58		2.84		15	----	nw.	----	----	----	----	----	----	----	----	----
Portland, Maine	103	82	117	29.92	30.00	+.05	68.5	+.4	95	26	76	54	2	60	29	63	60	82	3.18	−.1	14	6.8	s.	20	nw.	21	13	11	7	4.7	.0	.0
Concord	288	54	72	29.64	30.01	+.05	70.7	+2.2	96	26	83	45	3	59	38	64	61	77	7.18	+3.6	12	4.4	n.	21	n.	30	16	11	4	3.9	.0	.0
Burlington	403	11	48	29.57	30.00	+.06	68.4	−1.9	90	26	78	45	13	58	30	63	60	76	6.11	+2.6	14	6.3	s.	22	s.	24	6	14	11	5.9	.0	.0
Northfield	876	12	60	29.09	30.02	+.08	65.9	.0	91	26	79	38	13	53	39	60	58	85	2.11	−1.5	17	5.6	sw.	18	n.	31	4	16	11	6.7	.0	.0
Boston [1]	125	106	165	29.98	30.01	+.05	71.6	−.1	95	26	80	55	2	63	24	64	60	71	3.17	−.3	12	8.8	sw.	29	w.	30	9	15	7	5.5	.0	.0
Nantucket	12	14	90	30.02	30.04	+.06	67.6	−.2	88	27	74	55	2	69	21	64	62	88	2.35	−.5	8	11.2	sw.	28	ne.	12	7	12	12	5.7	.0	.0
Block Island	26	11	46	30.01	30.04	+.07	69.4	.0	86	27	75	55	4	62	21	65	63	87	2.21	−.9	7	11.3	sw.	30	ne.	4	17	10	4	3.6	.0	.0
Providence [2]	68	65	25	29.97	30.04	+.07	73.4	.0	97	27	83	55	3	64	28	65	62	79	3.24	.0	11	8.6	nw.	23	nw.	31	9	11	11	5.6	.0	.0
Hartford [3]	159	122	----	30.00	30.02	+.05	72.6	+1.0	95	26	83	51	2	62	31	66	64	80	3.88	−.5	10	6.9	sw.	24	ne.	22	5	12	14	6.5	.0	.0
New Haven [1]	13	74	68	30.02	30.04	+.07	73.0	+1.2	95	26	82	54	3	64	25	66	63	80	3.95	−.4	9	7.1	s.	21	nw.	11	7	15	9	5.8	.0	.0
Middle Atlantic States							**75.0**	**+0.1**										**75**	**3.56**	**−0.8**										**5.4**		
Albany [1]	292	26	40	29.70	30.01	+.05	71.0	−1.6	94	26	83	46	3	59	39	64	61	75	4.23	+.8	12	6.4	s.	25	ne.	22	6	15	10	6.2	.0	.0
Binghamton	871	57	79	29.14	30.05	+.08	71.0	+1.0	96	29	82	45	2	60	36	64	61	75	3.04	−.7	14	5.0	e.	17	sw.	29	2	10	19	7.3	.0	.0
New York	314	415	454	29.70	30.03	+.05	74.6	+.8	99	27	83	57	1	66	27	66	62	70	2.50	−1.7	11	10.9	sw.	57	nw.	11	9	13	9	5.3	.0	.0
Harrisburg [1]	374	94	104	29.68	30.05	+.07	76.5	+1.7	100	26	88	51	14	65	33	67	63	70	3.17	−.7	7	6.3	w.	34	se.	27	12	13	6	4.6	.0	.0
Philadelphia	114	174	367	30.01	30.04	+.06	77.2	+1.0	99	28	86	58	4	68	24	68	65	74	1.82	−2.3	11	10.2	sw.	43	n.	30	11	12	8	4.8	.0	.0
Reading	323	47	306	29.70	30.04	----	76.3	+.8	99	26	87	52	2	66	27	67	62	67	4.35	+.1	13	8.0	nw.	47	n.	27	14	11	6	4.7	.0	.0
Scranton	805	72	104	29.20	30.04	+.06	72.4	+.7	96	29	84	49	6	61	32	64	59	68	2.66	−1.4	12	5.4	n.	25	nw.	26	6	20	5	5.2	.0	.0
Atlantic City	52	37	172	29.99	30.04	+.06	73.4	+1.3	98	21	80	56	14	67	22	67	65	80	4.89	+1.0	10	12.8	s.	35	n.	4	10	13	8	5.2	.0	.0
Sandy Hook	22	10	57	30.02	30.04	----	73.2	−.3	94	26	81	56	3	66	22	67	65	81	4.10	−1.0	11	9.8	sw.	45	nw.	27	11	11	9	5.2	.0	.0
Trenton	190	89	107	29.84	30.04	----	75.6	+1.1	98	27	86	54	2	65	26	67	62	69	1.14	−2.8	8	7.3	s.	27	w.	30	5	12	14	6.4	.0	.0
Baltimore [3]	16	100	215	30.04	30.05	+.07	78.8	+1.6	101	27	88	59	4	69	24	70	66	72	2.85	−1.8	10	8.7	sw.	32	nw.	28	15	7	9	4.9	.0	.0
Washington	112	62	85	29.94	30.05	+.05	77.5	+.7	100	27	88	55	2	67	25	68	65	70	5.73	+1.0	8	5.2	sw.	23	nw.	28	14	9	8	4.9	.0	.0
Cape Henry	18	8	54	30.04	30.06	+.06	76.6	−.9	96	28	84	58	5	69	25	71	69	80	3.42	−2.0	10	8.6	sw.	42	ne.	23	13	9	9	5.0	.0	.0
Lynchburg	686	144	184	29.00	30.07	+.06	76.2	−1.3	101	28	87	53	14	66	30	68	66	75	5.45	+1.2	13	5.6	w.	41	n.	29	7	10	14	6.0	.0	.0
Norfolk [2]	91	80	125	30.04	30.07	+.07	78.6	−.1	104	27	88	62	2	70	27	71	69	81	3.44	−2.3	9	7.5	w.	30	nw.	28	10	7	14	6.0	.0	.0
Richmond [3]	164	11	52	29.89	30.07	+.06	76.6	−1.9	99	27	86	55	14	67	26	70	68	81	3.52	−1.2	11	6.0	sw.	20	ne.	24	10	12	9	4.9	.0	.0
Wytheville	2,304	49	55	----	30.12	+.11	70.0	−2.6	93	28	80	49	6	60	----	----	----	81	4.26	+.3	15	5.0	w.	24	ne.	28	3	15	13	----	.0	.0
South Atlantic States							**79.3**	**+0.1**										**79**	**4.23**	**−1.6**										**5.7**		
Asheville	2,253	89	104	27.83	30.12	+.10	72.8	+1.1	95	28	83	51	1	63	37	65	63	82	4.03	−.3	14	5.6	nw.	25	w.	24	5	12	14	6.7	.0	.0
Charlotte [2]	769	63	86	29.27	30.07	+.05	78.8	+.4	103	27	88	60	14	69	31	70	67	76	4.50	−.6	9	5.7	ne.	18	sw.	12	7	8	16	6.6	.0	.0
Greensboro [1]	886	6	56	29.17	30.10	----	75.4	----	99	27	85	54	14	65	28	69	67	82	6.08	----	14	6.0	ne.	35	n.	29	5	14	12	6.5	.0	.0
Hatteras	11	5	50	30.06	30.07	+.06	78.0	−.2	92	23	83	65	16	73	19	74	72	83	3.58	−1.9	8	9.9	sw.	40	nw.	23	12	9	10	5.1	.0	.0
Raleigh [2]	358	103	146	29.70	30.07	+.05	78.5	−.3	104	27	88	58	13	68	28	70	67	72	2.51	−2.9	7	7.3	sw.	28	n.	23	16	10	5	4.2	.0	.0
Wilmington	72	73	107	30.00	30.07	+.06	79.6	+.5	98	22	88	64	6	71	23	73	71	80	1.38	−5.8	7	7.6	sw.	29	s.	12	10	11	10	5.4	.0	.0
Charleston	48	11	92	30.02	30.07	+.04	81.4	.0	100	23	88	67	14	75	22	73	72	83	7.15	+.3	10	8.9	sw.	24	se.	16	13	8	10	5.4	.0	.0
Columbia, S. C. [2]	225	70	91	29.84	30.08	+.06	80.8	−.1	103	24	91	63	1	71	29	72	69	76	1.44	−3.9	11	6.9	s.	25	se.	27	10	9	12	5.3	.0	.0
Greenville, S. C.	1,040	70	78	29.01	30.09	----	77.8	+.9	103	27	87	60	5	68	30	----	----	----	4.60	−.8	11	5.8	ne.	17	sw.	11	8	10	13	6.2	.0	.0
Augusta [2]	426	62	77	29.62	30.07	+.05	80.8	−.5	99	23	90	63	1	72	31	71	68	75	3.43	−2.0	8	4.9	nw.	19	n.	30	9	9	13	6.1	.0	.0
Savannah [2]	51	73	152	30.02	30.07	+.04	81.8	+.3	101	26	90	68	9	73	27	75	73	84	5.43	−1.2	12	8.9	w.	34	sw.	3	14	4	13	5.6	.0	.0
Jacksonville	43	86	110	30.05	30.08	+.05	81.5	−.6	99	25	90	68	13	73	25	74	72	81	8.43	+1.7	23	6.6	s.	30	nw.	26	7	13	11	5.8	.0	.0
Florida Peninsula							**83.7**	**+1.8**										**78**	**3.71**	**−1.8**										**5.4**		
Key West [2]	21	10	64	30.03	30.04	+.01	84.4	+.9	92	30	90	73	3	79	16	78	76	77	4.59	+1.3	14	7.8	e.	34	s.	3	7	21	3	5.2	.0	.0
Miami	25	124	168	30.06	30.07	+.03	83.4	+2.4	92	25	89	70	4	78	18	76	74	80	1.92	−3.5	16	7.3	se.	25	se.	4	1	19	11	6.6	.0	.0
Tampa [2]	11	88	197	30.06	30.08	+.04	83.2	+2.0	94	12	92	71	18	75	21	76	73	78	4.63	−3.3	12	8.6	se.	35	se.	5	8	22	1	4.3	.0	.0
East Gulf States							**79.8**	**−1.2**										**82**	**9.98**	**+4.1**										**6.6**		
Atlanta [1]	976	5	72	29.07	30.07	+.05	77.2	----	98	28	86	58	7	68	28	70	67	79	8.82	----	13	7.4	nw.	28	w.	11	6	9	16	6.8	.0	.0
Macon [3]	464	79	87	29.58	30.07	+.05	79.2	−2.0	100	27	88	61	1	70	29	72	70	80	6.47	+1.7	16	5.2	s.	23	sw.	12	8	7	16	6.5	.0	.0
Thomasville	273	49	58	29.82	30.12	+.09	----	----	----	----	----	65	1	----	28	74	72	----	6.58	−.2	17	----	e.	----	----	----	----	----	----	----	.0	.0
Apalachicola	35	11	51	30.03	30.06	----	81.6	−.1	95	25	88	71	5	75	19	76	74	80	8.47	+.7	13	7.2	w.	26	se.	7	3	12	16	6.9	.0	.0
Pensacola	56	54	79	30.00	30.06	+.05	80.2	−.8	95	25	87	69	3	74	19	75	73	81	18.80	+12.0	17	6.6	w.	27	w.	3	4	13	14	6.8	.0	.0
Anniston	741	9	----	----	----	----	77.0	−.9	95	27	86	56	1	68	28	----	----	----	10.90	----	15	----	se.	----	----	----	10	7	14	----	.0	.0
Birmingham [3]	630	11	48	29.41	30.07	+.06	77.9	−2.3	96	28	86	61	1	70	24	71	69	80	8.27	+3.1	15	5.3	e.	20	nw.	12	8	9	14	6.5	.0	.0
Mobile [3]	29	86	161	30.02	30.05	+.04	80.7	−.7	96	22	88	68	4	74	21	75	73	86	9.82	+2.9	20	7.5	s.	29	sw.	3	4	15	12	6.5	.0	.0
Montgomery [3]	237	92	105	29.81	30.06	+.04	80.3	−1.4	99	28	88	65	1	72	22	73	72	84	6.15	+1.3	17	6.0	e.	21	ne.	28	10	5	16	6.4	.0	.0
Meridian [2]	310	67	92	29.72	30.04	+.02	79.4	−1.0	96	22	88	64	1	71	24	74	72	84	13.74	+8.8	17	5.3	sw.	26	w.	1	8	10	13	6.6	.0	.0
Vicksburg	247	82	102	29.77	30.02	+.02	79.4	−1.9	95	29	87	68	5	72	21	73	71	83	9.54	+4.9	18	7.0	sw.	27	ne.	17	8	8	15	6.5	.0	.0
New Orleans [2]	30	76	84	30.01	30.04	+.04	81.8	−.6	94	24	89	69	13	75	21	75	73	82	11.95	+5.6	17	5.1	sw.	24	w.	13	0	21	10	6.7	.0	.0
West Gulf States							**81.7**	**−0.9**										**76**	**2.93**	**−0.3**										**5.0**		
Shreveport [2]	181	92	227	29.83	30.02	+.04	81.8	−1.4	99	29	91	68	5	73	27	74	72	80	5.06	+1.5	11	8.9	s.	36	s.	29	13	9	9	4.7	.0	.0
Bentonville	1,303	12	51	28.68	30.01	+.04	77.0	−1.5	96	30	88	52	5	66	29	----	----	----	1.09	−3.2	5	5.7	s.	15	e.	18	14	9	8	4.6	.0	.0
Fort Smith	463	57	82	29.56	30.02	+.05	81.0	−.5	101	29	91	61	5	71	26	71	67	67	2.54	−.8	10	6.3	e.	21	s.	18	6	18	7	5.5	.0	.0
Little Rock [2]	265	94	102	29.75	30.03	+.04	78.8	−2.1	96	29	86	64	13	71	21	73	71	80	1.60	−1.9	12	7.2	s.	19	ne.	4	6	9	16	6.6	.0	.0
Austin [2]	605	68	90	29.36	30.00	----	82.1	−1.9	96	23	92	66	5	72	25	73	70	76	.57	−1.8	3	6.9	s.	23	ne.	2	10	16	5	4.8	.0	.0
Brownsville [2]	20	88	96	29.95	29.97	----	84.0	+.4	95	3	92	69	6	76	22	75	73	77	1.56	−.4	12	10.5	se.	32	ne.	3	5	22	4	5.1	.0	.0
Corpus Christi [2]	44	11	78	29.94	29.99	+.03	83.9	+1.2	92	11	90	70	13	78	20	76	74	83	4.02	+2.5	5	11.1	s.	32	ne.	3	18	9	4	3.7	.0	.0
Dallas [2]	488	220	227	29.48	29.99	----	80.6	----	97	30	89	64	5	72	22	73	70	71	3.82	+1.0	6	10.1	s.	50	n.	12	14	14	3	3.7	.0	.0
Fort Worth [1]	706	35	56	29.26	29.99	+.03	81.6	−2.0	98	30	92	60	5	72	25	72	68	70	2.86	+.2	4	9.9	s.	38	ne.	12	14	11	6	3.9	.0	.0
Galveston [2]	9	106	114	30.01	30.02	+.04	83.0	−.4	90	28	87	71	3	79	15	76	74	78	1.53	−2.2	7	9.8	s.	25	sw.	13	13	14	4	4.6	.0	.0
Houston [2]	62	157	190	29.95	30.01	----	83.4	−.3	97	10	92	70	6	75	22	74	72	82	2.79	−1.2	8	8.3	s.	27	se.	16	5	16	10	6.0	.0	.0
Palestine	510	64	72	29.50	30.02	+.05	80.4	−1.8	94	31	88	65	5	72	21	73	70	76	5.92	+3.2	6	6.5	s.	18	s.	15	12	14	5	4.8	.0	.0
Port Arthur	34	59	134	29.99	30.02	----	82.5	----	95	23	90	69	6	76	18	75	73	79	7.00	+.1	14	10.3	s.	34	w.	11	3	16	12	6.6	.0	.0
San Antonio [2]	582	111	301	29.39	29.99	+.04	83.7	−.1	99	31	94	66	5	74	25	74	71	73	.64	−1.5	6	10.6	se.	35	w.	2	7	20	4	5.0	.0	.0

See footnotes at end of table.

CLIMATOLOGICAL DATA FOR WEATHER BUREAU STATIONS—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max.+mean min.÷2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: maximum velocity: Miles per hour	Wind: maximum velocity: Direction	Wind: maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	° F.	° F.	° F		° F	° F		° F	° F.	° F.	° F.	%	In.	In.		Miles								0-10	In.	In.
Ohio Valley and Tennessee							**76.2**	**−0.2**										**71**	**2.54**	**−1.2**										**4.9**		
Chattanooga [1]	688	71	214	29.36	30.08	+0.06	76.6	−1.8	97	22	86	56	1	67	34	70	68	84	6.32	+2.1	19	4.4	s.	23	nw.	12	6	9	16	6.9	0.0	0.0
Knoxville [1]	980	66	84	29.06	30.09	+.07	77.0	−.1	97	29	86	60	5	68	26	69	66	78	2.46	−1.9	13	4.8	ne.	27	nw.	24	7	13	11	5.9	.0	.0
Memphis [1]	284	78	86	29.74	30.03	+.03	79.0	−1.7	97	30	86	62	4	72	20	72	70	78	4.11	+.9	14	6.5	sw.	25	n.	16	6	12	13	6.5	.0	.0
Nashville [1]	605	167	187	29.43	30.06	+.05	77.6	−1.5	97	29	86	61	17	69	24	70	67	75	2.17	−.9	12	6.8	s.	33	e.	30	10	10	11	5.9	.0	.0
Lexington	989	6		29.04	29.98	+.03	76.4	+.5	100	29	88	52	4	64	36				3.42	−.2	9		sw.				18	7	6	3.7	.0	.0
Louisville [1]	545	106	120	29.50	30.07	+.07	78.2	−.4	100	30	88	56	13	69	26	68	65	70	1.36	−2.3	4	7.4	sw.	24	n.	11	19	8	4	3.6	.0	.0
Evansville	431	76	116	29.60	30.06	+.06	79.2	+.3	100	30	89	57	13	70	25	69	64	65	2.07	−1.4	6	7.2	sw.	31	n.	16	14	11	6	4.2	.0	.0
Indianapolis [1]	808	98	129	29.22	30.06	+.07	77.6	+1.9	103	30	88	51	13	67	29	66	61	65	.90	−2.4	7	7.0	sw.	31	nw.	11	15	13	3	3.8	.0	.0
Terre Haute	575	68	149	29.45	30.05		77.7		100	25	89	52	13	67	28	67	61	59	2.25	−.9	7	7.7	sw.	26	sw.	22	14	13	4	4.2	.0	.0
Cincinnati [1]	497	11	51	29.55	30.07	+.07	76.2	+1.1	101	30	88	51	13	65	29	68	63	67	.33	−3.0	5	5.8	sw.	18	nw.	23	14	13	4	3.9	.0	.0
Columbus [1]	833	90	110	29.20	30.07	+.07	76.4	+1.5	99	30	87	50	13	65	31	66	62	66	.49	−3.1	6	7.9	s.	26	sw.	22	13	15	3	4.4	.0	.0
Dayton	900	186	213	29.14	30.07		75.5	+.1	98	29	86	49	13	65	28	66	60	62	1.00	−2.3	5	8.1	sw.	30	nw.	11	16	12	3	4.0	.0	.0
Elkins [1]	2,006	61	78	28.05	30.12	+.11	69.4	−.9	92	28	81	44	5	58	32	63	62	85	5.18	−.2	12	4.2	w.	25	nw.	29	5	15	11	6.2	.0	.0
Parkersburg	637	77	84	29.40	30.08	+.07	74.9	−.5	97	30	86	50	5	64	30	67	64	73	1.92	−2.4	10	4.7	se.	31	nw.	29	13	12	6	4.2	.0	.0
Pittsburgh [1]	1,273	39	54	28.75	30.08	+.08	73.4	−1.2	94	30	84	50	13	63	28	65	61	72	4.16	+.1	14	8.4	s.	38	nw.	29	7	13	11	6.0	.0	.0
Lower Lake Region							**72.1**	**+0.8**										**72**	**2.01**	**−1.3**										**4.5**		
Buffalo [1]	706	243	279	29.31	30.06	+.09	69.6	−.2	87	28	76	49	1	63	22	64	60	73	1.48	−1.6	9	11.1	sw.	40	nw.	26	15	11	5	4.5	.0	.0
Canton	448	10	61	29.55	30.01		69.2	+.3	89	26	80	47	3	59	31	63	59	73	3.76	+.3	13	6.2	w.	19	sw.	26	6	16	9	5.8	.0	.0
Ithaca	836	70	97	29.16	30.04		70.4	−.1	94	29	82	45	14	59	34				2.87	−.7	13	6.1	nw.	19	nw.	29	8	15	8	5.7	.0	.0
Oswego	335	71	85	29.67	30.04	+.08	68.9	−1.5	89	29	77	47	1	61	28	63	59	73	3.06	+.1	10	6.5	s.	26	nw.	29	10	16	5	4.6	.0	.0
Rochester [1]	555	86	102	29.46	30.05	+.08	72.0	+1.3	94	25	81	50	1	63	27	64	61	74	1.82	−1.1	9	7.2	sw.	22	w.	29	4	18	9	5.7	.0	.0
Syracuse [1]	408	65	79	29.60	30.04	+.07	71.3	+.7	94	29	80	48	13	62	27	64	61	74	2.32	−1.4	10	6.1	s.	25	nw.	29	6	16	9	5.9	.0	.0
Erie	714	57	81	29.29	30.07	+.09	72.4	+1.4	94	25	80	51	1	65	22	65	62	73	.95	−2.1	4	6.7	sw.	20	n.	11	16	14	1	3.4	.0	.0
Cleveland [1]	805	267	308	29.22	30.07	+.08	73.8	+2.4	95	29	81	53	1	66	22	66	62	70	.96	−2.5	6	11.4	n.	34	sw.	22	20	7	4	3.4	.0	.0
Sandusky	629	5	67	29.41	30.08	+.09	75.4	+2.0	100	24	85	52	1	66	28				1.47	−2.0	7	7.4	sw.	27	nw.	24	16	11	4	3.4	.0	.0
Toledo [1]	628	79	87	29.40	30.08	+.09	74.2	+1.0	98	24	84	50	1	64	26	66	62	72	3.29	+.3	7	8.4	w.	39	nw.	27	19	11	1	2.6	.0	.0
Fort Wayne [1]	828	69	84	29.20	30.07		75.0	+.5	98	24	86	51	4	64	28	66	61	67	.86	−2.7	5	7.5	sw.	30	nw.	27	15	13	3	4.2	.0	.0
Detroit [1]	626	5	78	29.41	30.07	+.09	73.4	+1.3	99	29	84	49	13	62	29	64	59	64	1.17	−2.2	8	8.3	sw.	29	nw.	24	12	14	5	4.8	.0	.0
Upper Lake Region							**69.8**	**+1.8**										**71**	**2.16**	**−1.0**										**4.9**		
Alpena	609	13	89	29.41	30.07	+.10	68.0	+2.1	89	24	77	47	13	59	26	62	58	71	3.51	+.8	8	8.7	nw.	41	nw.	29	9	17	5	4.8	.0	.0
Escanaba	612	51	72	29.41	30.06	+.09	66.8	+.8	83	25	74	47	2	59	26	62	58	76	4.58	+1.2	12	8.6	s.	34	nw.	23	10	9	12	5.4	.0	.0
Grand Rapids [1]	689	70	244	29.32	30.05	+.07	74.2	+1.9	99	25	85	48	2	64	28	64	60	65	.98	−1.9	7	9.4	sw.	37	sw.	25	17	8	6	4.2	.0	.0
Lansing	878	5	90		30.06		71.2	+.3	97	25	82	46	13	60	30			72	1.84	−1.3	9	6.8	sw.	32	nw.	24	17	13	1	3.7	.0	.0
Ludington	637	60	66																													
Marquette	734	44	73	29.25	30.04	+.08	67.4	+2.5	94	23	76	49	12	59	26	61	57	71	1.91	−1.2	9	7.1	e.	30	nw.	23	12	9	10	5.1	.0	.0
Sault Ste. Marie [1]	724	11	52	29.27	30.05	+.08	65.8	+2.0	94	23	77	44	2	55	37	59	55	76	1.62	−1.3	8	6.3	nw.	21	w.	14	6	15	10	5.9	.0	.0
Chicago	673	7	131	29.35	30.07	+.09	74.2	+1.7	101	25	83	52	4	65	29	64	60	66	1.29	−2.0	6	8.8	sw.	34	nw.	26	13	11	7	4.3	.0	.0
Green Bay	617	109	141	29.38	30.05	+.08	71.6	+1.6	96	23	81	48	12	62	26	64	60	68	1.90	−1.6	9	8.6	s.	31	n.	10	10	6	15	5.9	.0	.0
Milwaukee [1]	698	126	221	29.32	30.07	+.10	72.8	+2.7	102	25	81	52	2	65	34	64	60	70	.91	−1.9	7	10.3	w.	36	n.	25	14	13	4	4.5	.0	.0
Duluth	1,133	5	47	28.82	30.02	+.07	66.3	+2.4	91	23	76	44	12	56	32	60	56	72	3.05	.7	10	9.0	ne.	37	nw.	24	11	12	8	5.0	.0	.0
North Dakota							**71.9**	**+3.6**										**64**	**4.55**	**+2.0**										**4.9**		
Moorhead, Minn	899	50	58	29.02	29.97	+.03	72.6	+4.5	101	22	85	48	1	60	40	64	58	65	3.66	+.2	10	7.6	s.	31	nw.	22	13	14	4	4.2	.0	.0
Bismarck [1]	1,660	4	41	28.23	29.96	+.03	73.5	+3.7	99	23	88	47	2	59	42	63	57	63	3.35	+1.1	11	10.4	se.	36	n.	19	7	14	10	5.5	.0	.0
Devils Lake	1,478	11	44	28.43	29.98	+.05	70.2	+2.8	98	22	83	44	1	58	38	61	56	67	7.24	+4.7	15	7.5	e.	38	w.	24	10	16	5	5.4	.0	.0
Lemmon, S. Dak	2,602	4	38	27.28	29.94		74.5		102	13	89	52	7	60	43	61	54		3.79		10		se.								.0	.0
Grand Forks	832	12	67	29.10	29.98		70.8	+3.3	98	22	84	41	1	57	42	63	59		6.32	+3.6	14		se.				6	12	13		.0	.0
Williston	1,878	42	50	28.00	29.93	+.01	72.6	+3.7	97	13	85	50	29	60	36	61	55	59	2.20	+.3	8	6.5	se.	33	e.	22	12	15	4	4.6	.0	.0
Upper Mississippi Valley							**77.2**	**+2.1**										**63**	**2.90**	**−0.6**										**4.5**		
Minneapolis, St. Paul, Minn. [1]	838	32	61	29.11	29.99	+.04	75.8	+3.5	103	23	87	52	3	65	33	66	61	64	2.46	−1.3	11	8.5	s.	26	ne.	10	10	12	9	5.4	.0	.0
Springfield, Minn	1,025	4	42	28.91	29.98		76.4		105	24	89	48	2	63	33	65	60		.25		6		s.				10	14	7		.0	.0
La Crosse [1]	672	11	48	29.30	30.02	+.06	75.1	+2.3	99	23	85	51	13	65	34	66	62	69	2.26	−1.6	6	4.6	s.	13	nw.	10	10	7	14	6.0	.0	.0
Madison [1]	866	70	78	29.14	30.06	+.09	74.0	+1.9	97	24	84	53	12	64	27	65	60	66	3.38	−.5	7	6.8	s.	36	n.	10	9	13	9	5.4	.0	.0
Charles City	1,015	10	51	28.97	30.03	+.07	75.1	+2.8	102	24	86	50	3	64	32	65	60	63	10.35	+6.6	9	5.8	se.	23	se.	11	16	9	6	4.2	.0	.0
Davenport [1]	606	66	161	29.41	30.05	+.08	78.4	+3.1	103	25	89	54	13	68	27	66	60	58	2.05	−1.3	5	8.7	sw.	41	ne.	26	15	9	7	4.2	.0	.0
Des Moines [1]	963	5	99	28.99	30.00	+.04	78.7	+3.3	105	25	90	53	3	67	30	66	60	61	3.87	+.4	10	8.9	s.	37	n.	11	13	10	8	4.7	.0	.0
Dubuque	699	60	79	29.30	30.04	+.07	76.8	+2.7	102	25	87	52	13	66	29	66	61	63	3.71	−.2	10	5.5	s.	27	n.	25	11	13	7	4.8	.0	.0
Keokuk	614	64	78	29.38	30.03	+.05	78.7	+1.8	104	25	90	55	4	68	30	67	61	58	2.70	−.7	5	6.3	sw.	26	w.	15	17	10	4	3.7	.0	.0
Cairo	358	87	93	29.68	30.05	+.05	77.6	−2.0	96	31	86	59	4	69	22	70	67	75	1.39	−1.7	7	6.4	s.	32	n.	16	10	12	9	5.4	.0	.0
Peoria [1]	602	11	45	29.35	30.05	+.07	77.4	+2.0	104	25	90	49	4	65	35	66	61	61	.50	−3.1	7	4.8	s.	17	ne.	26	22	8	1	2.4	.0	.0
Springfield, Ill. [1]	613	5	191	29.40	30.05	+.07	78.8	+2.3	102	25	90	53	13	68	30	66	61	62	1.31	−1.6	4	9.4	s.	26	n.	27	14	10	7	4.4	.0	.0
St. Louis [1]	564	179	303	29.46	30.04	+.05	80.2	+1.4	102	29	90	56	13	70	25	67	61	56	.78	−2.2	2	10.0	sw.	30	n.	16	18	9	4	3.4	.0	.0
Missouri Valley							**79.9**	**+3.9**										**60**	**2.09**	**−1.6**										**4.5**		
Columbia, Mo. [1]	785	6	66	29.22	30.04	+.06	78.8	+1.9	101	29	90	54	5	68	31	68	63	66	2.06	−1.4	3	6.7	s.	21	w.	21	14	15	2	3.8	.0	.0
Kansas City [1]	750	38	76	29.20	29.99	+.02	81.6	+3.5	102	25	92	56	4	71	31	69	62	58	.80	−3.3	4	10.5	s.	26	sw.	25	16	11	4	3.8	.0	.0
St. Joseph [1]	817	11	49	29.14	29.99		80.4	+3.0	103	25	92	56	5	69	30	70	66	68	2.67	−1.1	5	8.1	s.	26	e.	11	15	13	3	2.9	.0	.0
Springfield, Mo. [1]	1,360	5	78	28.63	30.03	+.05	77.0	+.2	97	10	89	54	13	65	33	69	65	74	3.77	−.4	7	7.4	s.	21	w.	22	13	11	7	4.8	.0	.0
Topeka	987	65	87	28.94	29.97		82.6	+4.8	107	29	96	55	13	70	33	68	62	55	.08	−4.2	1	9.5	s.	23	ne.	11	11	15	5	4.0	.0	.0
Lincoln [1]	1,189	11	81	28.71	29.94	−.01	81.9	+5.4	110	25	94	52	4	69	34	66	58	53	2.02	−1.8	5	9.7	s.	33	w.	29	12	13	6	4.7	.0	.0
Omaha [1]	982	31	44	28.94	29.97	+.02	80.3	+3.6	108	25	92	53	3	68	30	68	61	58	1.56	−2.0	5	11.0	se.	34	se.	31	11	9	11	5.4	.0	.0
Valentine	2,598	46	54	27.28	29.93	.00	79.1	+5.4	108	24	92	52	3	66	36	64	56	52	2.51	−.5	7	10.4	e.	29	ne.	8	8	18	5	4.7	.0	.0
Sioux City [1]	1,138	64	106	28.82	29.97	−.01	78.4	+4.1	108	24	90	52	3	67	37	67	61	63	3.55	.0	10	9.5	s.	43	nw.	24	10	9	12	5.8	.0	.0
Huron [1]	1,289	26	41	28.60	29.94	.00	78.6	+6.8	110	24	92	51	2	65	37	65	57	55	1.90	−1.3	9	13.5	s.	36	s.	13	7	23	1	4.8	.0	.0
Northern Slope							**72.2**	**+4.5**										**53**	**1.36**	**−0.2**										**4.9**		
Billings [1]	3,570	18	39	26.33	29.91		74.6		102	22	90	49	28	59	43	59	50	52	.53		7	9.6	sw.	61	nw.	9	10	13	8	5.1	.0	.0
Havre	2,507	11	67	27.35	29.94	+.03	71.9	+3.6	98	23	86	48	7	58	41	58	50	56	1.11	−.8	9	8.1	e.	34	n.	25	17	12	2	3.5	.0	.0
Helena	4,124	85	111	26.04	29.94	+.01	70.4	+4.7	97	23	86	44	28	55	40	55	46	51	1.79	+.6	15	8.3	w.	43	sw.	9	11	10	10	5.4	.0	.0
Missoula [1]	3,189	80	91				71.8	+4.2	103	12	87	50	21	56	43	56	45	51	1.08	+.1	11	6.4	e.	37	sw.	20	10	16	5	4.5	.0	.0
Kalispell	2,973	48	56	26.93	29.92	+.01	68.2	+4.1	100	12	82	46	6	54	37	55	46	53	2.26	+1.2	11	5.7	w.	29	s.	20	6	20	5	5.2	.0	.0
Miles City [1]	2,634	48	55	27.22	29.90	−.02	77.2	+4.3	104	23	90	54	28	64	38	62	54	55	1.78	+.2	10	6.3	ne.	34	n.	24	13	13	5	4.8	.0	.0
Rapid City [1]	3,218	50	58	26.69	29.92	−.01	77.0	+6.0	105	23	90	57	12	64	37	61	52	50	.69	−1.7	10	7.7	s.	33	w.	29	18	11	2	3.9	.0	.0
Cheyenne [1]	6,144	5	39	24.09	29.96	+.04	70.1	+3.4	97	23	84	47	4	56	41	57	51	62	2.87	+.8	14	9.5	s.	35	ne.	29	4	17	10	6.3	.0	.0
Lander	5,352	60	68	24.72	29.88	−.04	72.6	+5.2	99	23	89	50	26	57	42	55	44	45	.27	−.4	3	5.5	sw.	29	w.	11	7	18	6	5.3	.0	.0
Sheridan [1]	3,790	10	47	25.96	29.91		73.2		102	23	90	44	28	56	48	59	50	52	.89	−.3	9	4.3	s.	21	nw.	24	5	21	5	5.6	.0	.0
Yellowstone Park	6,241	12	46	24.00	30.03	+.11	63.7	+2.8	87	12	78	36	28	49	38	50	42	54	1.57	+.3	9	7.2	sw.	28	w.	3	8	14	9	5.4	.0	.0
North Platte [1]	2,787	11	51	27.10	29.90	−.03	79.6	+6.7	109	24	92	57	2	67	35	64	57	54	.66	−2.1	10	8.3	s.	35	sw.	13	17	10	4	3.9	.0	.0

CLIMATOLOGICAL DATA FOR WEATHER BUREAU STATIONS—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max.+mean min.÷2	Temperature: Departure from normal	Temperature: Maximum	Temperature: Date	Temperature: Mean maximum	Temperature: Minimum	Temperature: Date	Temperature: Mean minimum	Temperature: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F		°F	°F		°F	°F.	°F.	°F.	%	In.	In.		Miles								0–10	In.	In.
Middle Slope							79.7	+2.5										57	1.72	−1.1										4.4		
Denver [2]	5,332	106	113	24.80	29.94	+0.03	74.6	+2.4	99	24	87	52	3	63	32	58	49	53	0.62	−1.1	10	7.2	s.	29	se.	26	7	14	10	6.0	0.0	0.0
Pueblo [2]	4,806	79	86	25.25	29.91	.00	76.8	+2.6	104	8	93	52	4	61	47	50	50	50	1.01	−.9	11	8.8	e.	42	w.	21	5	21	5	5.5	.0	.0
Concordia	1,392	50	58	28.51	29.94	−.01	82.8	+4.8	110	25	95	55	4	71	31	68	61	53	1.03	−2.8	7	9.0	s.	23	e.	1	16	11	4	3.9	.0	.0
Dodge City	2,509	10	86	27.38	29.91	−.02	82.0	+3.6	107	26	95	56	4	69	35	65	57	52	1.52	−1.6	5	12.2	s.	40	nw.	1	15	14	2	3.9	.0	.0
Wichita [2]	1,392	85	93	28.53	29.95	−.01	81.4	+2.0	105	24	92	58	4	70	30	69	64	64	.94	−2.4	3	10.9	se.	32	s.	9	19	8	4	3.5	.0	.0
Oklahoma City [2]	1,304	10	47	28.64	29.98	+.02	80.4	−.2	100	20	91	59	4	70	31	70	66	68	5.21	+2.4	7	9.6	s.	30	nw.	1	17	9	5	3.6	.0	.0
Chadron, Nebr	3,439	4	58	26.47	29.88	------	80.0	------	108	23	94	55	2	66	40	62	51	---	.81	------	6	------	e.	----	------	---	---	---	---	----	.0	.0
Southern Slope							82.1	+1.2										53	0.68	−1.7										3.6		
Abilene [2]	1,750	10	56	28.18	29.95	+.02	83.7	+.9	102	11	95	60	5	72	30	69	62	59	.12	−2.0	1	10.4	s.	27	s.	27	17	11	3	3.2	.0	.0
Amarillo [2]	3,604	10	49	26.37	29.90	−.02	82.0	+5.2	106	9	95	58	3	69	36	63	53	46	.88	−2.0	5	9.8	s.	27	ne.	20	24	7	0	2.5	.0	.0
Del Rio	960	63	71	28.96	29.92	+.02	83.9	−2.4	99	25	94	67	6	74	26	71	65	59	.08	−2.3	2	10.2	se.	28	se.	15	8	19	4	4.9	.0	.0
Roswell	3,566	75	85	26.41	29.92	+.04	79.8	+.9	101	9	93	60	8	67	37	63	53	48	1.64	−.6	6	7.9	s.	38	ne.	11	16	11	4	4.0	.0	.0
Southern Plateau							80.1	+1.5										41	0.60	−1.1										4.2		
El Paso [3]	3,916	82	101	26.07	29.87	+.03	83.4	+2.3	104	11	95	66	18	72	33	63	52	43	1.06	−.9	8	8.0	e.	29	n.	5	15	15	1	3.8	.0	.0
Albuquerque [1]	5,314	5	34	24.82	29.88	------	78.2	+1.5	98	10	92	55	5	64	38	61	53	51	.62	−.8	10	9.3	se.	45	ne.	4	8	15	8	5.3	.0	.0
Santa Fe	7,013	38	53	23.42	29.99	+.11	70.6	+1.6	90	7	83	49	5	58	33	54	45	47	.72	−1.7	11	5.9	e.	17	e.	20	4	19	8	6.1	.0	.0
Flagstaff	6,907	10	59	23.48	29.86	+.03	67.4	+2.4	91	7	83	40	19	52	43	50	37	40	.52	−2.6	5	7.5	nw.	27	w.	23	11	13	7	4.9	.0	.0
Phoenix [2]	1,112	39	87	28.68	29.78	.00	91.5	+1.7	113	4	106	66	17	77	40	66	50	30	.66	−.4	5	6.3	w.	29	se.	17	14	11	6	4.2	.0	.0
Yuma	142	9	54	29.65	29.79	+.03	91.6	+.8	116	12	108	65	20	75	41	68	53	35	T	−.2	0	5.2	sw.	20	se.	13	27	4	0	1.1	.0	.0
Independence	3,957	5	26	25.95	29.89	+.06	78.2	+.1	103	5	95	52	19	62	40	54	29	---	.00	−.1	0	5.4	------	----	------	---	---	---	---	----	.0	.0
Middle Plateau							75.3	+2.4										33	0.27	−0.3										3.1		
Ely	6,262	5	41	------	------	------	------	------	---	---	---	---	---	---	---	---	---	---	----	------	---	------	------	----	------	---	---	---	---	----	----	----
Reno [2]	4,400	61	76	25.61	29.95	+.08	70.8	+.7	96	5	87	50	10	54	40	52	40	48	.50	+.2	3	7.1	w.	23	se.	16	22	7	2	2.2	.0	.0
Tonopah	6,090	12	20	24.10	29.89	------	74.5	------	95	5	87	54	17	62	32	51	29	---	.0	------	0	------	se.	----	------	---	---	---	---	----	.0	.0
Winnemucca	4,344	18	56	25.61	29.90	.00	72.4	+1.8	98	5	92	43	21	52	51	51	31	29	.11	−.1	1	7.0	sw.	24	nw.	15	22	7	2	2.7	.0	.0
Modena	5,473	10	43	24.67	29.88	+.02	71.6	+1.0	97	24	89	42	21	54	48	50	30	26	T	−1.1	0	11.5	sw.	30	sw.	19	19	8	4	3.1	.0	.0
Salt Lake City [2]	4,227	86	210	25.72	29.84	−.06	81.0	+5.3	102	7	94	60	2	68	36	57	41	30	.09	−.4	2	8.0	s.	26	se.	16	19	10	2	2.9	.0	.0
Grand Junction	4,602	60	68	25.40	29.89	.00	80.8	+3.1	103	24	94	60	18	67	33	58	43	34	.64	.0	6	7.1	se.	28	s.	16	9	18	4	4.5	.0	.0
Northern Plateau							73.0	+3.0										42	0.92	+0.4										4.4		
Baker [2]	3,373	36	54	26.53	29.95	.00	68.7	+3.1	100	11	85	40	6	52	46	54	46	59	.57	.0	4	5.5	n.	19	sw.	20	14	12	5	4.3	.0	.0
Boise [1]	2,858	5	49	26.98	29.86	−.07	74.9	------	99	11	91	50	28	59	41	56	42	38	.36	------	4	8.8	nw.	35	sw.	16	16	11	4	3.9	.0	.0
Pocatello [1]	4,478	5	31	25.48	29.87	−.05	74.0	------	101	12	91	50	28	57	49	54	37	31	.21	------	3	9.3	sw.	28	se.	10	7	18	6	5.1	.0	.0
Spokane [2]	1,968	101	110	27.88	29.91	−.05	72.8	+3.8	101	11	85	52	31	60	42	57	46	46	1.46	+.8	4	6.0	s.	20	s.	17	12	12	7	4.5	.0	.0
Walla Walla	991	57	65	28.87	29.92	−.05	76.3	+2.3	101	11	88	57	31	65	34	58	44	36	1.22	+.8	3	6.3	s.	21	sw.	12	14	10	7	4.3	.0	.0
Yakima	1,076	58	67	28.79	29.92	------	74.4	+3.0	100	11	88	52	31	61	34	58	45	41	.45	+.1	6	6.8	nw.	20	nw.	12	13	12	6	4.1	.0	.0
North Pacific Coast Region							64.9	+1.5										70	0.96	+0.3										6.0		
North Head	211	5	56	29.87	30.09	+.01	58.8	+1.6	68	30	63	50	8	54	13	56	55	90	1.73	+.8	13	13.0	n.	33	n.	6	1	13	17	7.6	.0	.0
Seattle [2]	14	90	321	30.01	30.04	.00	66.0	+2.9	88	1	75	51	6	57	33	57	51	67	.73	+.1	4	8.3	s.	24	s.	1	7	15	9	6.0	.0	.0
Tacoma	194	172	201	29.85	30.05	−.01	64.7	+1.9	87	1	74	48	6	56	33	----	----	---	1.11	+.5	4	8.0	sw.	22	w.	30	6	9	16	6.5	.0	.0
Tatoosh Island	86	9	61	29.98	30.07	+.02	56.0	+.9	63	26	59	49	10	53	11	54	53	91	2.58	+1.0	14	9.5	s.	28	s.	28	3	8	20	8.0	.0	.0
Medford [1]	1,329	29	58	28.59	29.97	------	71.0	−.7	94	1	87	48	6	56	42	58	48	52	.14	−.2	1	------	nw.	----	------	---	17	10	4	3.4	.0	.0
Portland, Oreg. [2]	39	68	106	29.99	30.03	−.02	69.0	+2.3	94	1	79	51	6	59	34	59	53	63	.39	−.2	7	6.5	nw.	16	nw.	3	7	11	13	6.1	.0	.0
Roseburg	510	45	76	29.49	30.03	.00	69.1	+1.7	90	11	82	48	6	56	37	58	51	59	.07	−.2	2	5.2	n.	16	n.	3	13	13	5	4.1	.0	.0
Middle Pacific Coast Region							68.4	+1.1										62	T	0.0										3.9		
Eureka	60	72	88	30.02	30.09	+.04	58.0	+2.5	68	12	62	47	6	54	17	55	53	87	.0	−.1	0	6.6	n.	19	sw.	15	4	14	13	6.5	.0	.0
Redding [1]	722	20	34	29.14	29.90	------	80.3	−1.5	103	5	93	61	18	68	30	59	42	29	.0	−.1	0	7.8	nw.	24	nw.	25	21	9	1	2.4	.0	.0
Sacramento [2]	25	92	115	29.89	29.91	+.03	74.9	+1.7	103	5	91	55	18	59	43	60	50	51	.0	.0	0	8.2	s.	18	sw.	30	28	3	0	1.0	.0	.0
San Francisco	155	112	132	29.81	29.98	+.03	60.2	+1.7	79	5	65	52	8	55	23	56	53	82	T	.0	0	11.3	w.	28	w.	31	9	16	6	4.8	.0	.0
South Pacific Coast Region							73.1	0.0										60	T	0.0										2.9		
Fresno [1]	327	89	98	29.60	29.89	+.06	80.4	−1.7	107	5	98	56	17	63	40	62	48	39	.0	.0	0	7.5	nw.	20	nw.	15	24	6	1	1.5	.0	.0
Los Angeles	512	223	250	29.41	29.95	+.05	70.6	+.4	93	13	82	56	20	60	31	60	55	66	T	.0	0	5.7	w.	18	w.	11	19	12	0	2.8	.0	.0
San Diego [2]	28	62	70	29.92	29.95	+.03	68.4	+1.2	86	10	75	58	21	62	24	62	59	76	T	.0	0	7.4	w.	20	nw.	12	11	14	6	4.5	.0	.0
West Indies																																
San Juan, P. R.	82	10	54	29.97	30.06	------	81.0	+.9	88	8	85	74	1	77	12	----	----	---	2.44	−2.5	14	12.3	e.	34	e.	17	9	17	5	5.0	.0	.0
Panama Canal																																
Balboa Heights	118	6	92	[4]29.73	[4]29.82	.00	82.0	1.7	93	1	88	72	20	76	18	----	----	84	[6]6.23	−1.0	14	6.6	nw.	21	nw.	4	0	16	15	7.3	.0	.0
Cristobal	36	6	97	[4]29.81	[4]29.84	.00	82.3	1.9	90	1	86	73	20	78	12	77	76	83	[6]15.90	0.4	19	8.5	n.	25	nw.	23	0	2	29	9.2	.0	.0
Alaska																																
Fairbanks	454	11	87	[4]29.43	[4]29.93	------	62.0	+2.0	89	17	74	42	31	50	37	54	47	65	.94	−1.0	13	5.8	w.	27	sw.	13	2	9	20	7.7	.0	.0
Juneau	80	96	116	[4]29.91	[4]30.00	------	58.8	+1.7	81	16	65	46	1	52	27	54	51	78	4.46	−.7	13	6.2	s.	24	se.	9	4	7	20	7.9	.0	.0
Nome	22	5	59	[4]29.85	[4]29.87	------	51.5	------	65	20	55	39	26	48	13	50	48	88	2.72	------	21	11.8	se.	26	sw.	14	0	3	28	9.3	.0	.0
Hawaiian Islands																																
Honolulu	38	86	100	29.96	30.00	------	79.4	+1.7	85	19	84	72	24	75	13	71	67	68	.43	−.8	12	9.9	e.	25	e.	7	9	18	4	5.0	.0	.0

[1] Data are airport records.
[2] Barometric and hygrometric data from airport, other data city office records.
[3] Observations taken bihourly.
[4] Pressure not reduced to a mean of 24 hours.
[5] Barometric, hygrometric, and temperature records from airport, other data from city office records.
[6] Barometric data from airport records, other data from city office record.

NOTE.—Except as indicated by notes 1, 2, 5, and 6, data in table 2 are city office records.

SEVERE LOCAL STORMS

[Compiled by MARY O. SOUDER from reports submitted by Weather Bureau Officials]

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A revised list of tornadoes will appear in the United States Meteorological Yearbook]

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Buffalo, Okla., vicinity of	1	4 p. m.	[1] 2-6		$150,000	Hail	Loss to crops, $100,000; property damage and loss of farm animals, $50,000 path 30 miles long.
Woodward, Okla., and vicinity.	1	5:45 p. m.	[1] 10		5,000	Hail, wind and rain.	Loss to crops, principally wheat, $4,000; property damage, $1,000; path 20 miles long.
Ryus, Kans., and vicinity	1	6 p. m.	[1] 3-4		8,000	Heavy hail	Wheat total loss in some localities; windows broken; buildings damaged; path 12 miles long.
Weatherford, Okla	1	6 p. m.	[1] 3		300,000	do	Loss in wheat and other crops, $50,000: damage to building and other property, $250,000: farm animals killed; path 3 miles long.
Eagle Nest, N. Mex., 1 mile west.	3	4:26-5:30 p. m.	[1] 3		7,300	do	$4,600 loss to crops; $2,700 damage to roofs.
Great Falls, Mont., 12 miles east.	5			0		Tornado	This storm traversed only range land and caused no property loss nor personal injuries.
Teton County, Mont	5				12,000	Hail	Loss to crops.
Alexandria, S. Dak., western portion.	6	3 p. m.				Heavy hail	In some sections, total loss in small grains; path narrow and 1 to 1½ miles long.
Blout, S. Dak., 5 miles south	6	7 p. m.			10,500	do	Storm severe; stones large. Crop loss, $10,000; property damage, $500.
Rockham, S. Dak., vicinity of.	6	7-8 p. m.			5,000	Wind and rain	Several buildings demolished; no crop loss.
Mead and Haakon Counties, S. Dak.	6	8 p. m.	[1] 6			Heavy hail	Crops destroyed, principal loss to corn in spots; path 40 miles long.
Redfield, S. Dak., vicinity of	6	8:50 p. m.				Wind and rain	0.80 inch of rain recorded in 12 minutes; trees and small buildings damaged; path narrow.
Aurora County, S. Dak	6	9:30-10:30 p. m.	[1] 2		3,300	Wind and hail	Chickens and turkeys killed; crop loss, $3,300.
Portales, N. Mex., vicinity of	7	4-5 p. m.	[1] 3		1,000	Heavy hail	Loss to crops.
Nickerson to Valley, Nebr	8	2-4 p. m.			20,000	Wind and hail	Loss in corn, wheat, and oats; path 15 miles long.
Monona, Crawford, Harrison, and Shelby Counties, Iowa.	8	6:30-11:30 p. m.			985,000	Hail, heavy rain and flood.	This storm started in Monona County at 6:30 p. m., where damage ranged up to 80 percent of the total crops. In the last 3 counties named there was almost complete destruction of crops from a hailstorm that started at 10 p. m. Nearly 600 farms were affected with severe damage on about 400. 11 bridges washed out in Shelby County. Railroad roadbeds washed; bus and train service delayed; property damaged; livestock lost; 75,000 acres of crops total loss.
Portsmouth, Iowa	8	11:30 p. m.		0	100,000	Tornado	25 persons injured, several seriously. Greatest loss in business district with only 2 buildings escaping serious damage; path 10 miles long.
Ruble to Correctionville, Iowa.	8		[1] 1-2		40,000	Hailstorms	There were 3 separate storms, each with a differing area of most intense damage. About 200 farms affected with some losses. Property damage, $3,000; loss to crops, $37,000; path 30 miles long.
Northland and Fisher, Minn., and vicinities.	9	1:50 p. m.	[1] 2½		20,000	Hail, thunderstorm, heavy rain.	Considerable damage to growing crops, some fields of grain a total loss; property damaged; much poultry perished. Loss to crops, $20,000; path 18 miles long.
Woodbine, Logan, and Calhoun, Iowa, and vicinities.	9				40,500	Heavy rain and flood.	The Boyer, Willow, and Soldier Rivers overflowed their banks following the downpour of rain. Loss in crops and gardens; basements flooded.
Audubon, Guthrie, and Adair Counties, Iowa.	10	3 a. m.			10,000	Heavy hail	Property damaged.
Minnesota, extreme southeastern counties.	10	5 p. m.	[1] 5		99,000	Thundersqualls	General direction of the storm from northwest to southeast over a path 90 miles long; much property damaged.
Pierce and St. Croix Counties, Wis.	10	6:30-7 p. m.	[1] 10		18,000	Heavy hail	Property damage, $3,000; loss to crops, $15,000; path 15 miles long.
O'Brien County, Iowa	10	8:30-10:30 p. m.			20,000	Straight-line wind	Trees uprooted; corn flattened; 4 barns completely wrecked.
Calhoun County, Iowa	10	P. m.			10,000	Wind, electrical	Power lines and trees down; farm buildings damaged.
South Dakota, most counties along eastern edge.	10	do			100,000	Wind, rain, and hail.	Buildings, automobiles, farm machinery, and windmills wrecked; trees broken, livestock killed; crop loss negligible to 100 percent. Estimated damage more than $100,000.
Minnesota, extreme southeastern counties.	10		[1] 3		227,000	Hail	In Fillmore County more than 200 farmers lost their entire crops, while 150 others lost part of their crops; path 30 miles long.
Cherryvale, Kans	11	4:30-6 p. m.	[1] 6			Thundersquall and hail.	Farm buildings, power and telephone lines damaged by wind; loss to crops from hail; path 7 miles long.
Atchison, Doniphan, and Leavenworth Counties, Kans.	11	5:50-7:30 a. m			15,000	Wind and rain	Some farm buildings damaged or totally destroyed. Flooding occurred in Leavenworth County.
Ponca City, Okla., and vicinity.	11	6 p. m.	[1] 2		500	Wind	Property damaged; path 35 miles long.
Big Spring, Nebr	11	7-9 p. m.	[1] 4	3	50,000	Hail and excessive rain	6,000 acres of wheat destroyed by hail; bridge washed out. Passenger automobile and truck plunged into flooded gulch, killing 3 persons.
Oklahoma City and Norman, Okla.	11	8:15 p. m.	[1] 3		13,000	Wind	Wind of 70 miles per hour recorded at the Oklahoma City Airport with considerable damage to the hangar of the Southwest Aviation & Service Co., when the roof and doors were blown off the building and several planes damaged to the extent of $10,000. Near Norman crop loss was estimated at $1,000 with property damage of $2,000. Path 20 miles long.
Blanchard, Okla	11	9 p. m.	[1] 4		2,500	do	This storm believed to be a portion or extension of the one that occurred at Oklahoma City Airport. Property damaged; slight loss in broomcorn crop.
Putnam County, Ind	11				1,000	do	Property damaged.
Centerville, N. Mex	12	P. m.	2,640		500	Heavy hail	Loss to crops.
Daniels, Sheridan, and Roosevelt Counties, Mont.	13	4:45-6 p. m.	[1] 8		450,000	Hail and wind	Loss to crops, $400,000; property damage, $50,000; path 150 miles long.
Rosebud County, Mont	13	8:50 p. m.	[1] 5		2,500	Hail	Loss in wheat and oats; path 30 miles long.
Valley County, Mont	14		880		8,500	do	Crop loss, $8,500; small property damage; path 20 miles long.
Randolph County, Ind	15	6 p. m.	880			do	Much crop loss.
Byers, Colo	15	3 p. m.	[1] 1		1,250	Heavy hail	Considerable damage in small area; loss to crops, $1,250.
Jefferson County, Mont	16	2 p. m.	[1] 10			Wind and hail	Loss in wheat and oats, $5,000; property damage, $2,000; path 15 miles long.
Gallatin, Mont	16	2:45-3:30 p. m			2,700	Wind	Property damaged.
Fergus County, Mont	17	5:30 p. m.	[1] 3			Hail and wind	Loss in wheat and hay, $15,000; property damage, $1,500; path 14 miles long.
Wibaux County, Mont	18		[1] 4		10,000	do	Grain and corn total loss; path 6 miles long.
Thomas, S. Dak., vicinity of	19	5 a. m.		0	5,000	Tornado	Several small buildings, windmill, large barn and silo wrecked; crop loss negligible, not estimated; path narrow.
McLaughlin, S. Dak	19	6 p. m.	[1] 4			Heavy hail	Loss in crops; path 6 miles long.
Perkins, S. Dak	19	P. m.				Wind and hail	Grain total loss on several farms; farm buildings wrecked; 1 person injured by flying timber; path narrow.
Atwood and Bilby, Okla	20	11:45 a. m.	[1] 2		21,000	Wind and heavy hail.	Wind damage to crops, $3,000; property damage, $3,000; crops loss from hail principally to cotton, $15,000; path 30 miles long.
Coalgate, Okla	20	12:45 p. m.	[1] 4		700	Wind	Crop loss, $200; property damage, $500; path 20 miles long.
De Witt, Nebr	21	Noon	100	0	2,000	Tornado	Barn moved on its foundation and 2 sheds destroyed.
Deerbrook, Wis., and vicinity.	21	2 p. m.	[1] 2		3,000	Wind	Large barn and 2 garages blown down, another damaged; path 5 miles long
Wichita, Kans	21	4:32-4:37 p. m		0		Small tornado	Vortex cloud observed about 2 miles northeast of Wichita Airport, but did not reach the ground.
Miller, S. Dak., vicinity of	21	P. m.		0		Tornado	Barn, garage, and 2 windmills destroyed; minor loss to crops; path barrow.

[1] Miles instead of yards.

SEVERE LOCAL STORMS—Continued

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Clio, S. C	22	4 p. m			1,000	Electrical	Barn, with implements and livestock burned.
Canton, Okla	22	6 p. m	[1]4		7,700	Wind and hail	Loss in cotton, corn and feed crops, $17,000; property damage, $6,000; path 6 miles long.
Major, Blaine, and Dewey Counties, Okla.	22	6-6:30 p. m	[1]4		100,000	Heavy hail	Loss in crops; property damaged; path 20 miles long.
Taloga, Okla	22	8 p. m	1,320		19,000	Hail and wind	Damage to property from wind, $12,000, from hail, $2,000; crop loss from hail, $5,000; path 2 miles long.
Stiles Junction to Oconto, Wis.	23	2 p. m	[1]2		5,000	Wind	Barn demolished, 2 others and a residence damaged; several smaller buildings blown down. Property damage, $4,000; loss to crops, $1,000.
Menasha to Appleton, Wis	23	2:55-4:10 p. m.	[1]2		5,000	Hail and wind	Loss to crops; path 25 miles long.
Daniels County, Mont	23	4-6 p. m	[1]4		70,000	do	Crop loss, $60,000; property damage, $10,000; path 20 miles long.
Artesia, S. Dak., vicinity of	23	5 p. m			18,000	Wind	Several farm buildings destroyed; 2 persons injured.
Danville to Mount Morris, N. Y.	23				300,000	Torrential rain	Bridges damaged; small section of the roadbed of the Pennsylvania Railroad washed out; highways covered with debris; some roads under 4 feet of water. Crops in lowland ruined. Estimated loss of entire crops, $100,000; property damage, $200,000.
Parkston, S. Dak., vicinity	23			0		Tornado	Church lifted from its foundation and destroyed; barn wrecked.
Minnesota, extreme northern counties.	24	2-5 a. m	[1]25		300,000	Thundersqualls	Much property damaged; loss in growing crops; hundreds of trees uprooted; livestock killed; several persons injured; path 200 miles long.
Mahnomen County, Minn., northern portion.	24	2:30 a. m			10,000	Hail	Loss to growing crops.
Fergus County, Mont	24	P. m	880		10,000	do	Loss in crops; path 2 miles long.
Pondera and Teton Counties, Mont.	24	3 p. m			50,000	do	Loss in mustard, wheat, oats, and barley; path 25 miles long.
Mercer, Wis	24	9:30-10:15 p. m.			600	do	Chief damage to roofs and windows; minor loss to crops.
Blaine County, Mont	25	11 a. m	[1]6		3,000	do	Loss in wheat; path 20 miles long.
Carbon County, Mont	25	12:30 p. m	[1]1		25,000	do	Loss in wheat, oats, and hay; path 8 miles long.
Richland County, Mont	25	2 p. m	880		12,000	Hail and wind	Loss in crops; path 4 miles long.
Springfield, S. Dak., vicinity of.	25	5 p. m	880		10,000	Wind	Church demolished; roofs, small buildings, windmills, and trees damaged.
Rock and Walworth Counties, Wis.	25	6-6:30 p. m				Thundersquall	Barn demolished; house under construction wrecked; many trees blown over; electric service disrupted; man injured and livestock killed.
Haigler, Nebr	25	8 p. m	[1]4		6,000	Hail and wind	Loss in corn and sorghums from hail, $5,000; wind damage to property, $1,000.
Jackson County, Iowa	25-26	P. m			10,000	Electrical	Several barns struck by lightning and burned.
Truchas, N. Mex	26	3-4 p. m	440		500	Heavy hail	Loss in crops.
Lincoln County, Kans	26	7 p. m			10,000	Wind	Damage to farm buildings and residences; 1 person injured.
Massena, N. Y., vicinity of	26			1		Thunderstorm	Much damage to trees, telephone, and power lines. Girl killed by lightning.
Custer County, Mont	27	4:40 p. m	[1]2		5,500	Wind and hail	Storm mostly over range land; loss in crops, $5,000; property damage, $500; path 40 miles long.
Scott City, Kans., northwest of.	27	5 p. m	[1]1-5		2,500	Wind	Most damage to small buildings. Wind violent in some portions. Path 10 miles long.
Nebraska City, Nebr., vicinity of.	27	5:45 p. m	100	0	10,000	Tornado	Farm buildings wrecked; power lines damaged.
Sidney and Hamburg, Iowa	27	6 p. m		0	15,000	Tornadic wind and hail.	Property damage, $12,000; crop loss, $3,000.
Mount Ayr, Iowa, 6 miles northwest.	27	7 p. m	33	0	1,500	Tornado	Property damaged; path several miles long.
Clayton County, Iowa	27	11:20 p. m	[1]10		28,000	Hail	Loss to crops, path 10 miles long.
La Crosse, Kans., and vicinity.	27	P. m			800	Wind	Some small buildings blown down; minor damage to residences.
Pauline, S. C., vicinity of	27				1,000	Electrical	Garage and barn, with feed, burned.
Audubon, Iowa	27-28				1,000	Heavy rain and flood.	Western section of town flooded; 8 families removed from homes.
Indianola, Iowa	28	1 a. m			500	Wind	Buildings unroofed.
Orogrande, N. Mex., vicinity of.	28	4:40-5 p. m		0		Tornado	No damage because the storm occurred in an unoccupied area.
St. Paul, Minn	29	A. m			5,000	Rain and flood	Sewers overflowed; basements flooded.
Lincoln, Nebr., 2 miles south	29	5 p. m	100	0	5,000	Tornado	Barns and outbuildings on 4 farms damaged.
Ames, Iowa, vicinity of	30	1:30 a. m			22,000	Electrical	A fraternity house and the Iowa State College Farm's grain elevator burned.
Granite and Powell Counties, Mont.	30	9:27 p. m	[1]2		30,200	Hail	Loss in crops, $30,000; property damage, $200; path 30 miles long.
Newton, Iowa, vicinity of	31	2:30 a. m			2,500	Electrical	Barn and contents burned.
Raymond, Minn., vicinity of	31	7 p. m	[1]1		2,000	Thundersquall	Property damaged; path 24 miles long.
Hastings, Nebr	31	do	[1]1		30,000	High wind	Roofs blown off; plate glass broken; outbuildings wrecked; 3 persons cut by flying glass.
Utica, Nebr	31	8:30 p. m	[1]1		3,000	do	Barns and outbuildings damaged or demolished on 3 farms.
Lemmon, S. Dak	31	9:15 p. m				Wind and hail	Widespread damage to buildings and crops.

[1] Miles instead of yards.

SOLAR RADIATION AND SUNSPOT DATA FOR JULY 1940

SOLAR RADIATION OBSERVATIONS

By HELEN CULLINANE

Measurements of solar radiant energy received at the surface of the earth are made at nine stations maintained by the Weather Bureau, and at 10 cooperating stations maintained by other institutions. The intensity of the total radiation from sun and sky on a horizontal surface is continuously recorded (from sunrise to sunset) at all these stations by self-registering instruments; pyrheliometric measurements of the intensity of direct solar radiation at normal incidence are made at frequent intervals on clear days at three Weather Bureau stations (Washington, D. C., Madison, Wis., Lincoln, Nebr.) and at the Blue Hill Observatory at Harvard University. Occasional observations of sky polarization are taken at the Weather Bureau stations at Washington and Madison.

The geographic coordinates of the stations, and descriptions of the instrumental equipment, station exposures, and methods of observation, together with summaries of the data obtained, up to the end of 1936, will be found in the MONTHLY WEATHER REVIEW, December 1937, pp. 415 to 441; further descriptions of instruments and methods are given in Weather Bureau Circular Q.

Table 1 contains the measurements of the intensity of direct solar radiation at normal incidence, with means and their departures from normal (means based on less than 3 values are in parentheses). At Lincoln the observations are made with the Marvin pyrheliometer; at Washington, Madison, and Blue Hill they are obtained with a recording thermopile, checked by observations with a Smithsonian silver-disk pyrheliometer at Washington and Blue Hill. The table also gives vapor pressures at 7:30 a. m. and at 1:30 p. m. (75th meridian time).

Table 2 contains the average amounts of radiation received daily on a horizontal surface from both sun and sky during each week, their departures from normal and the accumulated departures since the beginning of the year. The values at most of the stations are obtained from the records of the Eppley pyrheliometer recording on either a microammeter or a potentiometer.

Direct solar radiant energy averaged below normal at all stations, although the month contained an unusually large number of clear days at Blue Hill, Madison, and Washington.

There was an excess of total solar and sky radiation at every station with the exception of Fairbanks and Friday Harbor, where it was practically normal, and Blue Hill and Miami, where there was some deficiency.

Polarization measurements made at Madison on 10 days give a mean of 57.0, compared with a normal for July of 59 percent. The maximum was 66.3 on the 3d, very close to the July normal.

TABLE 1.—*Solar radiation intensities during July 1940*

[Gram-calories per minute per square centimeter of normal surface]

Date	7:30 a. m. (75th mer. time)	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	1:30 p. m. (Local mean solar time)
		Air mass A. M.					Air mass P. M.				
	e	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
WASHINGTON, D. C.											
July 2	9.83					1.14					9.14
July 5	11.38	0.58	0.66	0.76	0.95	1.37					8.81
July 6	9.83	.50	.59	.72	.97	1.26					8.81
July 8	12.24	.49	.55	.68	.74	1.14					12.24
July 10	16.20				.58						14.10
July 15	12.24				1.14	1.20					12.68
July 18	16.79				.87						13.13
July 19	17.96	.54	.65	.80	.96	1.09					17.96
July 20	17.37	.52	.54	.55	.64	1.12					16.79
July 25	19.23		.44	.65	.74	1.03					19.23
July 26	21.28				.89	1.06					19.23
July 27	19.80	.49	.52	.58	.77	1.08					19.23
July 29	19.23				.69						18.59
July 30	18.59		.44	.54	.68	1.02					20.57
July 31	18.59			.68	.83						17.96
Means		.53	.57	.66	.89	1.14					
Departures		−.05	−.10	−.14	−.03	−.07					
LINCOLN, NEBR.											
July 13	7.87	0.64	0.75	0.88	1.09	1.39					7.87
July 18	16.79		.72	.82							13.61
July 19	13.61	.68	.80	.94	1.12	1.44	0.97				10.21
July 24	18.59	.67	.77	.90	1.12	1.44					11.81
Means		.67	.76	.88	1.11	1.40	(.97)				
Departures		−.02	−.03	−.04	+.02	+.06	−.10				
MADISON, WIS.											
July 2	8.81	0.83	0.91	1.04							8.81
July 3	10.59	.76	.91	1.03	1.22	1.34					9.14
July 5	10.97	.57	.71	.87	1.06	1.32					10.59
July 6	11.81	.61	.71	.87	1.02	1.20					9.83
July 8	15.65				1.06	1.25					12.68
July 10	16.79	.52	.61	.60	.74	1.23					13.61
July 12	8.48	.84	.95	1.07	1.22	1.45					9.14
July 13	7.87	.83	.92	1.02	1.14	1.40					6.76
July 15	13.61	.40	.49	.64	.81						9.83
July 17	9.14	.71	.81	.95	1.10						9.47
July 22	16.20		.69	.84	1.06	1.28					16.20
July 23	17.96	.49	.59	.75	1.01						15.11
Means		.66	.75	.88	1.04	1.31					
Departures		−.02	−.03	−.03	−.03	+.01					
BLUE HILL, MASS.											
July 1	8.8	0.86	0.96	1.06	1.20	1.33					8.6
July 2	9.6	.88	.97	1.08	1.22	1.38					8.6
July 3	8.8	.67	.76	.86	1.08	1.27					10.3
July 6	10.7	.76	.90	1.00	1.14	1.29	1.05	0.82	0.69		10.7
July 7	11.5	.68	.77	.88	1.07	1.30	.92	.72	.56		11.5
July 8	11.5					1.26	.91	.66	.51		10.3
July 9	14.3		.41	.72							14.7
July 10	15.3	.36	.47	.61	.76	1.11		.68	.53		12.8
July 14	9.2	.82	.91	1.03	1.22	1.34	1.12	.87	.73	0.60	9.6
July 15	10.3	.61	.70	.80	1.00	1.27	.92	.66			11.1
July 16	12.8	.44	.56	.70	.90	1.15					14.7
July 18	16.3					.86					16.4
July 19	16.4	.23	.35	.48	.73	1.19	.98	.81			15.8
July 21	18.6					1.21	.78				16.9
July 23	15.8							.61	.49	.40	16.9
July 27	19.5						.78	.63	.51		18.8
July 28	15.3				.92	1.18					15.3
July 31	16.9	.68	.80	.94	1.10	1.30					14.7
Means		.63	.72	.85	1.03	1.21	.93	.72	.58	(.50)	
Departures		+.01	−.03	−.02	−.02	−.05	−.08	−.14	−.14	−.17	

*Extrapolated.

TABLE 2.—*Average daily totals of solar radiation (direct + diffuse) received on a horizontal surface)*

[Gram-calories per square centimeter]

Week beginning—	Washington	Madison	Lincoln	Chicago	New York	Fresno	Albuquerque	Fairbanks	Twin Falls	La Jolla	Miami	New Orleans	Riverside	Blue Hill	Newport	Friday Harbor	Ithaca	Cambridge
	cal.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
July 2	562	745	690	631	584	711	709	529	....	484	477	360	628	548	602	707	560	571
July 9	570	627	625	545	485	727	712	507	....	623	465	396	622	476	493	610	484	496
July 16	624	661	583	568	448	711	648	419	....	631	498	544	660	392	400	627	479	433
July 23	633	408	538	512	437	708	634	354	....	522	466	553	600	455	484	436	420	522
DEPARTURES FROM WEEKLY NORMALS																		
July 2	+44	+202	+60	+145	+106	−2	....	+60	....	−73	00	−45	+21	−42	+66	+126	+29	....
July 9	+67	+81	+25	+70	+31	+27	....	+32	....	+31	−37	−3	+33	−48	−4	+21	+18	....
July 16	+142	+131	+2	+96	+19	+15	....	−15	....	+60	−11	+122	+88	−109	−44	−13	−11	....
July 23	+143	−104	−23	+37	+17	+14	....	−80	....	+24	−44	+156	+52	−9	−10	−160	+7	....
ACCUMULATED DEPARTURES ON JULY 29, 1940																		
	+3,885	+3,962	−931	+3,787	+5,964	−889	....	+2,639	....	−4,571	+1,652	+5,574	−1,134	−4,151	−2,419	+5,810	....	

POSITIONS, AREAS, AND COUNTS OF SUN SPOTS

[Communicated by Capt. J. F. Hellweg, U. S. Navy (Ret.), Superintendent, U. S. Naval Observatory.] All measurements and spot counts were made at the Naval Observatory from plates taken at the observatories indicated. Difference in longitude is measured from the central meridian, positive toward the west. Latitude is positive toward the north. Areas are corrected for foreshortening and expressed in millionths of Sun's hemisphere. For each day, under longitude, latitude, area of spot or group, and spot count, are included assumed longitude of center of the disk, assumed latitude of center of the disk, total area of spots and groups, and total spot count.

Date	Eastern standard time	Mount Wilson group No.	Heliographic				Area of spot or group	Spot count	Plate quality	Observatory
			Difference in longitude	Longitude	Latitude	Distance from center of disk				
1940	*h m*		°	°	°	°				
July 1	11 1	6893	−74	215	+9	74	242	3	G	U. S. Naval.
		(*)	−33	256	−5	34	24	4		
		6892	−11	278	−21	26	24	5		
		6888	+19	308	−15	26	145	15		
		6887	+21	310	+2	21	61	1		
		6888	+28	317	−14	33	194	1		
		6891	+32	321	−1	32	6	2		
		6889	+38	327	+9	38	145	19		
		6878	+78	7	−11	79	12	1		
		6877	+81	10	−18	81	291	1		
				(289)	(+3)		1,144	52		
July 2	11 49	6894	−80	195	−26	80	206	1	F	Do.
		6893	−61	214	+10	61	145	4		
		6888	+31	306	−16	36	121	7		
		6887	+34	309	+2	34	61	1		
		6888	+41	316	−15	45	194	3		
		6889	+52	327	+8	52	145	6		
				(275)	(+3)		872	22		
July 3	10 38	6897	−79	183	−9	79	48	1	P	Mt. Wilson.
		6894	−67	195	−24	70	97	1		
		6893	−48	214	+11	49	145	4		
		6896	+1	263	−8	11	24	3		
		6895	+7	269	+6	8	48	4		
		6888	+45	307	−16	49	97	7		
		6887	+48	310	+2	48	48	1		
		6888	+56	318	−15	60	145	3		
		6889	+66	328	+8	66	97	6		
				(262)	(+3)		749	30		
July 4	14 33	6897	−62	185	−11	64	61	1	G	U. S. Naval.
		6894	−51	196	−25	59	85	1		
		6893	−33	214	+11	34	97	7		
		6896	+14	261	−8	18	12	1		
		(*)	+25	272	−5	27	24	1		
		(*)	+32	279	+5	32	24	4		
		6887	+62	309	+2	62	24	1		
		6888	+69	316	−15	70	145	3		
		6889	+81	328	+9	81	48	1		
				(247)	(+3)		520	20		
July 5	10 57	6900	−51	185	+15	52	6	1	G	Do.
		6897	−50	186	−10	52	48	5		
		6899	−44	192	−15	49	61	6		
		6894	−39	197	−25	47	73	1		
		6898	−33	203	+12	34	73	9		
		6893	−20	216	+10	21	48	3		
		(*)	+51	287	+5	51	6	1		
		6887	+73	309	+2	73	12	1		
		6888	+82	318	−15	82	145	1		
				(236)	(+3)		472	28		

POSITIONS, AREAS, AND COUNTS OF SUN SPOTS—Con.

Date	Eastern standard time	Mount Wilson group No.	Heliographic				Area of spot or group	Spot count	Plate quality	Observatory
			Difference in longitude	Longitude	Latitude	Distance from center of disk				
1940	*h m*		°	°	°	°				
July 6	10 49	6897	−36	187	−10	38	36	1	F	Mt. Wilson.
		6899	−31	192	−15	36	73	8		
		6894	−26	197	−25	37	73	1		
		6898	−19	204	+12	21	145	18		
		6893	−6	217	+11	10	12	1		
		(*)	+60	283	+5	60	24	5		
				(223)	(+3)		363	34		
July 7	9 10	6897	−31	179	−8	33	6	1	VG	Do.
		6901	−28	182	+18	32	6	1		
		6900	−26	184	+16	28	12	3		
		6897	−23	187	−9	26	36	4		
		6899	−15	195	−13	22	48	7		
		6894	−13	197	−25	31	73	1		
		6898	−7	203	+13	11	218	25		
				(210)	(+4)		399	42		
July 8	11 19	6903	−65	131	−13	67	6	1	G	U. S. Naval.
		6901	−15	181	+17	20	145	6		
		6897	−10	186	−9	16	24	1		
		6900	−10	186	+12	13	6	2		
		6899	−4	192	−12	15	48	5		
		6894	0	196	−25	29	73	1		
		6898	+9	205	+12	12	242	10		
		6902	+14	210	+18	21	66	11		
				(196)	(+4)		610	38		
July 9	10 57	6905	−89	94	+6	89	48	2	G	Do.
		6903	−56	127	−8	58	48	3		
		6904	−20	163	+22	26	24	6		
		6901	−1	182	+16	12	315	35		
		6897	+3	186	−9	13	6	4		
		6900	+3	186	+11	8	6	3		
		6899	+10	193	−12	19	97	7		
		6894	+13	196	−25	31	48	1		
		6898	+20	203	+12	22	97	13		
		6898	+25	208	+13	27	194	1		
		6902	+27	210	+18	31	582	24		
				(183)	(+4)		1,465	99		
July 10	10 56	6905	−76	94	+5	76	970	11	VG	Do.
		6903	−41	129	−11	43	109	13		
		6904	−6	164	+22	19	133	12		
		6901	+14	184	+15	18	194	31		
		6899	+24	194	−11	29	73	12		
		6894	+27	197	−24	39	24	1		
		6898	+34	204	+12	36	48	13		
		6898	+39	209	+12	40	194	1		
		6902	+42	212	+18	44	727	29		
				(170)	(+4)		2,472	123		
July 11	12 27	6905	−63	93	+5	63	921	8	G	Do.
		6903	−26	130	−11	30	170	11		
		6904	+9	165	+21	19	267	14		
		6901	+28	184	+15	22	170	20		
		6899	+40	196	−11	43	48	4		
		6894	+40	196	−24	48	24	1		
		6898	+49	205	+12	50	48	5		
		6898	+52	208	+12	53	194	1		
		6902	+55	211	+18	57	1,164	17		
				(156)	(+4)		3,006	81		

Date	Eastern standard time	Mount Wilson group No.	Heliographic				Area of spot or group	Spot count	Plate quality	Observatory
			Difference in longitude	Longitude	Latitude	Distance from center of disk				
1940	h m		°	°	°	°				
July 12...	9 6	6906	−66	78	+8	66	24	6	VG	Mt. Wilson.
		6905	−49	95	+6	49	970	20		
		6903	−13	131	−10	19	145	14		
		6904	+20	164	+22	28	48	17		
		6904	+26	170	+20	30	194	4		
		(*)	+39	183	−11	42	12	3		
		6901	+42	186	+15	44	339	35		
		6894	+53	197	−24	60	12	1		
		6899	+54	198	−11	56	36	6		
		6898	+66	210	+12	66	194	4		
		6902	+67	211	+18	67	1,164	20		
				(144)	(+4)		3,138	130		
July 13...	11 0	6906	−53	77	+7	53	48	9	VG	U. S. Naval.
		6905	−35	95	+6	35	727	25		
		6903	+1	131	−11	15	48	12		
		6904	+32	162	+21	36	73	15		
		6904	+39	169	+21	41	194	1		
		6901	+56	186	+14	57	194	27		
		6899	+67	197	−11	68	12	3		
		6898	+79	209	+13	79	194	1		
		6902	+79	209	+19	79	679	6		
		6902	+88	218	+20	88	485	1		
				(130)	(+4)		2,654	100		
July 14...	11 3	6907	−71	46	−10	71	48	3	G	Mt. Wilson.
		6906	−39	78	+7	40	24	6		
		6905	−22	95	+7	23	727	26		
		6903	+17	134	−11	23	48	4		
		6904	+51	168	+21	53	194	5		
		6901	+70	187	+14	70	48	2		
				(117)	(+4)		1,089	46		
July 15...	11 3	6909	−86	17	−16	86	97	2	G	U. S. Naval.
		6907	−59	44	−11	60	73	3		
		6906	−26	77	+7	27	24	1		
		6905	−8	95	+5	8	727	26		
		6903	+31	134	−11	35	24	1		
		6904	+66	169	+22	67	194	4		
				(103)	(+4)		1,139	37		
July 16...	12 16	6909	−72	17	−17	75	194	9	G	Do.
		6907	−46	43	−11	49	24	4		
		6906	−12	77	+6	13	12	3		
		6905	+6	95	+6	7	630	22		
		6908	+23	112	−6	25	48	2		
		6903	+44	133	−11	47	24	2		
		6904	+79	168	+21	79	194	2		
				(89)	(+4)		1,126	44		
July 17...	8 41	6909	−65	13	−16	68	24	3	VG	Mt. Wilson.
		6909	−58	20	−15	60	73	4		
		6910	−50	28	−14	52	6	1		
		6907	−33	45	−13	37	18	2		
		6905	+18	96	+7	18	533	30		
		6908	+33	111	−7	35	24	7		
		6903	+55	133	−10	57	6	2		
				(78)	(+5)		684	49		
July 18...	11 7	6909	−52	12	−17	56	24	1	G	U. S. Naval.
		6909	−43	21	−16	47	73	5		
		6910	−38	26	−15	43	6	1		
		6907	−19	45	−12	26	12	7		
		6905	+32	96	+8	33	485	28		
		(*)	+33	97	−4	34	6	1		
		6911	+60	124	−10	62	6	1		
				(64)	(+5)		612	44		
July 19...	11 14	6914	−75	335	+8	75	48	1	G	Do.
		6913	−63	347	+10	63	48	5		
		6912	−53	357	+26	55	12	7		
		6909	−38	12	−16	43	24	5		
		6910	−29	21	−15	35	12	3		
		6907	−7	43	−12	19	12	6		
		(*)	+9	59	−2	11	6	3		
		6905	+47	97	+8	47	436	12		
		6911	+74	124	−10	76	97	9		
				(50)	(+5)		695	51		
July 20...	10 27	6915	−72	326	−14	74	6	1	G	Do.
		6914	−61	337	+8	61	12	4		
		6913	−50	348	+10	50	73	20		
		6912	−39	359	+26	43	24	7		
		6909	−24	14	−14	31	6	3		
		6910	−15	23	−12	21	6	2		
		6907	+8	46	−11	18	6	3		
		6905	+60	98	+8	60	388	11		
		6911	+88	126	−11	88	145	1		
				(38)	(+5)		666	52		
July 21...	11 5	6917	−71	313	−8	73	24	2	G	Do.
		6915	−58	326	−11	60	24	6		
		6914	−49	335	+9	49	24	5		
		6913	−36	348	+10	36	24	4		
		6912	−27	357	+26	34	48	14		
		6909	−12	12	−14	22	12	9		
		6910	−1	23	−12	16	6	4		
		(*)	+29	53	+13	30	24	4		
		6905	+72	96	+10	72	291	1		
		6905	+72	96	+5	72	48	1		
				(24)	(+5)		525	50		
July 22...	8 43	6917	−59	313	−8	60	24	3	G	Mt. Wilson.
		6914	−37	335	+10	38	24	1		
		6913	−24	348	+11	25	24	4		
		6912	−14	358	+27	26	36	5		
		6919	−10	2	−17	24	24	10		
		6918	−3	9	−17	22	12	6		
		6916	+9	21	+23	20	24	3		
		6910	+10	22	−14	22	6	10		
		6905	+86	98	+9	86	242	1		
				(12)	(+5)		416	43		
July 23...	8 37	6920	−65	294	+7	65	12	2	F	Do.
		6917	−45	314	−7	48	12	4		
		(*)	−37	322	−13	42	6	2		
		6919	+4	3	−19	24	145	36		
		6918	+12	11	−18	26	6	4		
		6910	+22	21	−12	27	12	10		
				(359)	(+5)		193	58		
July 24...	12 6	6921	−73	271	−11	75	48	4	G	U. S. Naval.
		6920	−49	295	+5	49	12	3		
		6917	−31	313	−7	34	12	1		
		(*)	−12	332	+8	13	12	3		
		6919	+19	3	−20	31	194	29		
				(344)	(+5)		278	40		
July 25...	10 58	6921	−61	270	−11	63	194	6	F	Do.
		6917	−18	313	−7	22	12	3		
		6919	+32	3	−20	40	242	20		
		6922	+49	20	+24	51	24	5		
				(331)	(+5)		472	34		
July 26...	12 8	6923	−69	248	−10	70	48	3	F	Do.
		6921	−47	270	−10	50	267	15		
		6917	−5	312	−7	12	6	2		
		6919	+45	2	−20	51	339	11		
				(317)	(+5)		660	31		
July 27...	10 51	6923	−62	243	−10	64	73	10	F	Do.
		6923	−57	248	−11	59	121	1		
		6921	−33	272	−10	36	291	15		
		6917	+10	315	−8	16	6	3		
		6919	+59	4	−19	62	339	9		
				(305)	(+5)		830	38		
July 28...	12 4	6924	−82	209	+18	82	485	3	G	Do.
		6923	−48	243	−10	51	73	11		
		6923	−42	249	−11	45	170	3		
		6921	−19	272	−10	24	267	19		
		6919	+69	0	−21	71	24	1		
		6919	+77	8	−19	79	291	13		
				(291)	(+6)		1,310	50		
July 29...	11 6	6924	−77	201	+20	77	242	1	G	Do.
		6924	−68	210	+19	69	485	8		
		6925	−53	225	−12	56	48	7		
		6923	−33	245	−9	36	24	4		
		6923	−28	250	−11	34	194	6		
		6921	−10	268	−9	18	24	4		
		6921	−3	275	−8	15	145	9		
				(278)	(+6)		1,162	39		

Date	Eastern standard time	Mount Wilson group No.	Heliographic: Difference in longitude	Heliographic: Longitude	Heliographic: Latitude	Heliographic: Distance from center of disk	Area of spot or group	Spot count	Plate quality	Observatory
1940	h m		°	°	°	°				
July 30...	12 4	6924	−63	201	+20	64	218	2	G	Do.
		6924	−55	209	+19	56	436	8		
		6925	−39	225	−12	42	73	8		
		6923	−13	251	−10	21	218	13		
		6926	−10	254	+8	10	73	9		
		6921	+11	275	−8	19	97	5		
				(264)	(+6)		1,115	45		
July 31...	11 1	6924	−50	202	+19	51	194	2	G	Do.
		6924	−42	210	+18	44	339	12		
		6925	−27	225	−12	32	97	19		
		6923	−5	247	−8	15	48	8		
		6923	+1	253	−10	16	194	1		
		6926	+3	255	+8	3	97	11		
		6921	+22	274	−8	26	24	9		
		6921	+24	276	−8	29	73	2		
				(252)	(+6)		1,066	64		

Mean daily area for 31 days=1,029.

*Not numbered.
VG=very good; G=good; F=fair; P=poor.

PROVISIONAL RELATIVE SUNSPOT NUMBERS

[Dependent on observations at Zurich only. Data furnished through the courtesy of Prof. W. Brunner, Eidgen. Sternwarte, Zurich, Switzerland]

July 1940	Relative numbers	July 1940	Relative numbers	July 1940	Relative numbers
1	91	11	*a* 125	21	52
2	67	12	126	22	*Mc* 58
3	77	13	101	23	*a* 34
4	47	14	76	24	34
5	*Ec* 56	15	62	25	*Ec* 48
6	*Mc* 44	16	*a* 74	26	37
7	*a* 56	17	*Wc* 60	27	*Ec* —
8	*Mcc* 68	18	62	28	*d* 59
9	*Eac* 97	19	66	29	*a* 53
10	*Mcd* 122	20	67	30	59
				31	*Maac* 67

Mean, 30 days=68.2.

a=Passage of an average-sized group through the central meridian.
b=Passage of a large group through the central meridian.
c=New formation of a group developing into a middle-sized or large center of activity; E, on the eastern part of the sun's disk; W, on the western part; M, in the central-circle zone.
d=Entrance of a large or average-sized center of activity on the east limb.

U. S. GOVERNMENT PRINTING OFFICE: 1940

Chart I. Departure (°F.) of the Mean Temperature from the Normal, and Wind Roses for Selected Stations, July 1940

Chart I. Departure (°F.) of the Mean Temperature from the Normal, and Wind Roses for Selected Stations, July 1940

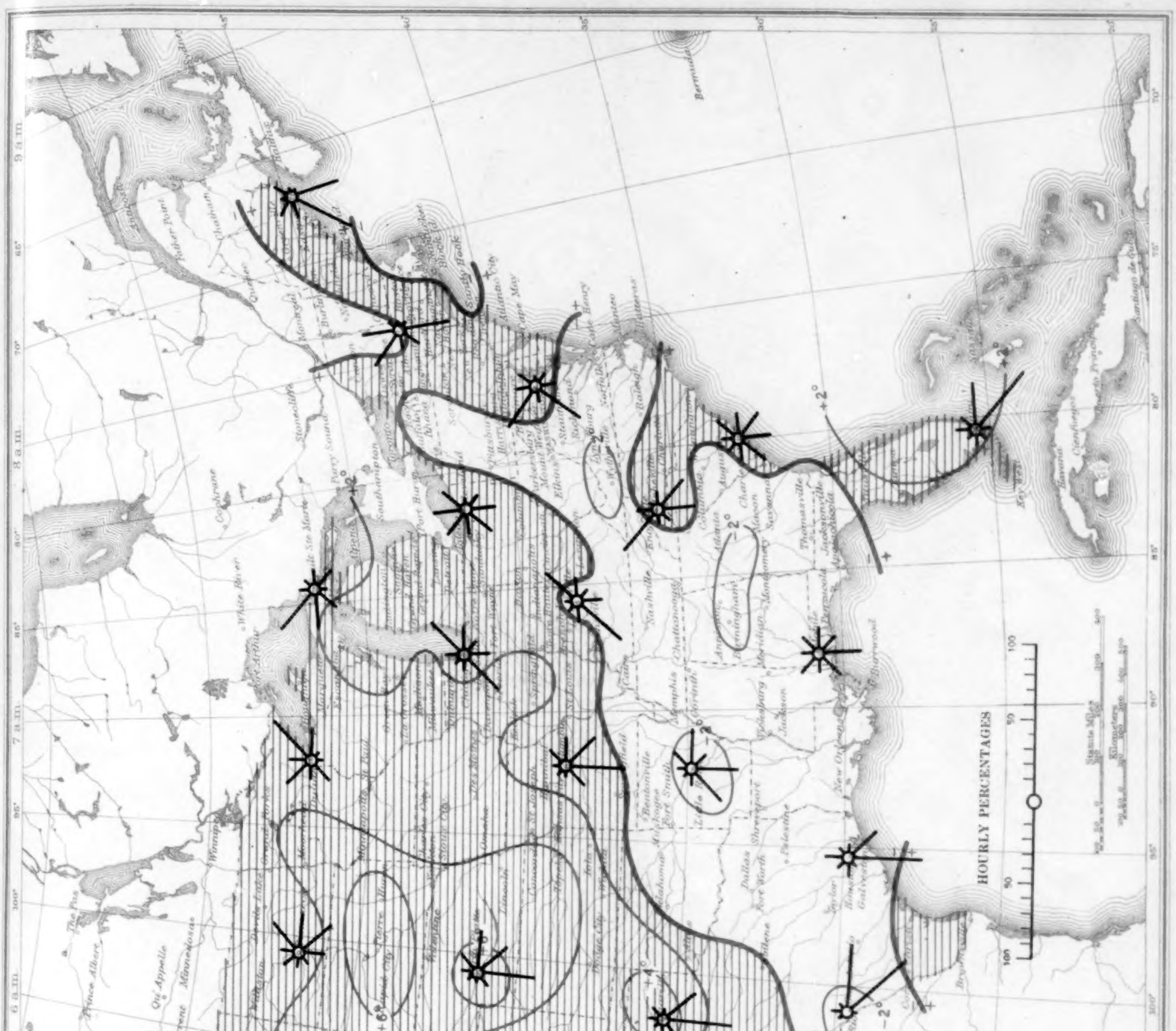
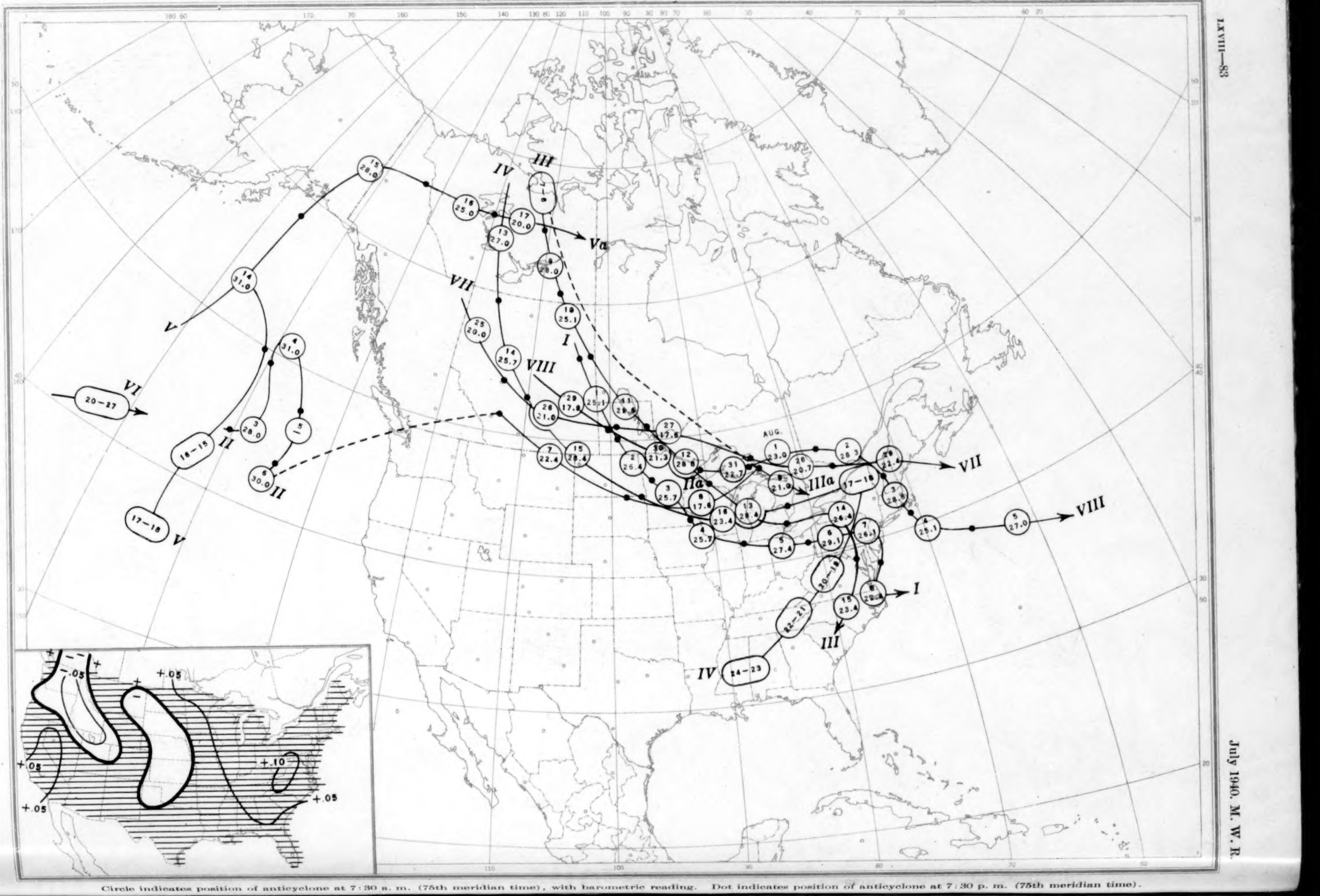


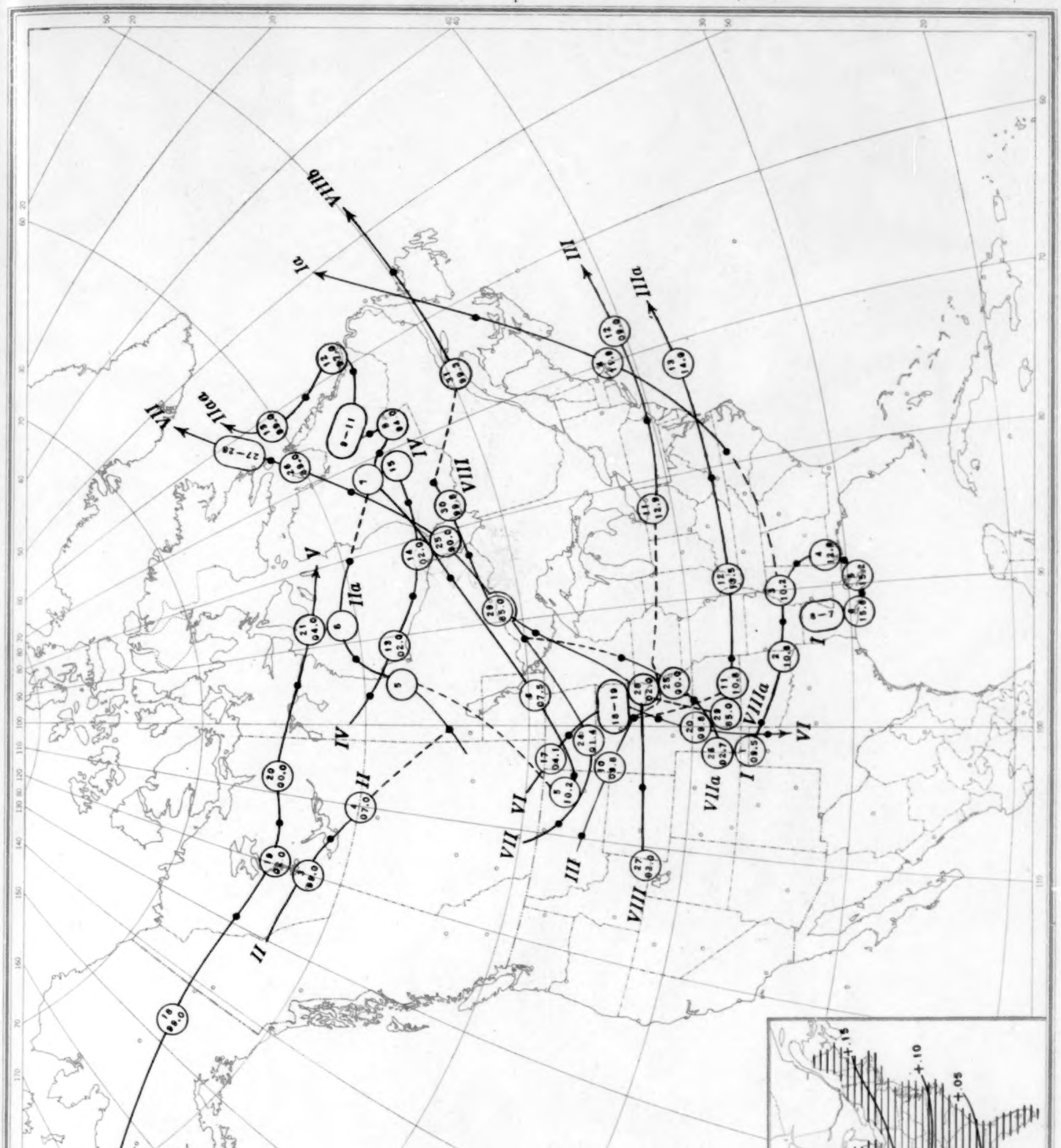
Chart II. Tracks of Centers of Anticyclones, July 1940. (Inset) Departure of Monthly Mean Pressure from Normal



Circle indicates position of anticyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 7:30 p. m. (75th meridian time).

Chart III. Tracks of Centers of Cyclones, July 1940. (Inset) Change in Mean Pressure from Preceding Month

Chart III. Tracks of Centers of Cyclones, July 1940. (Inset) Change in Mean Pressure from Preceding Month



Circle indicates position of cyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of cyclone at 7:30 p. m. (75th meridian time).

Chart IV. Percentage of Clear Sky Between Sunrise and Sunset, July 1940

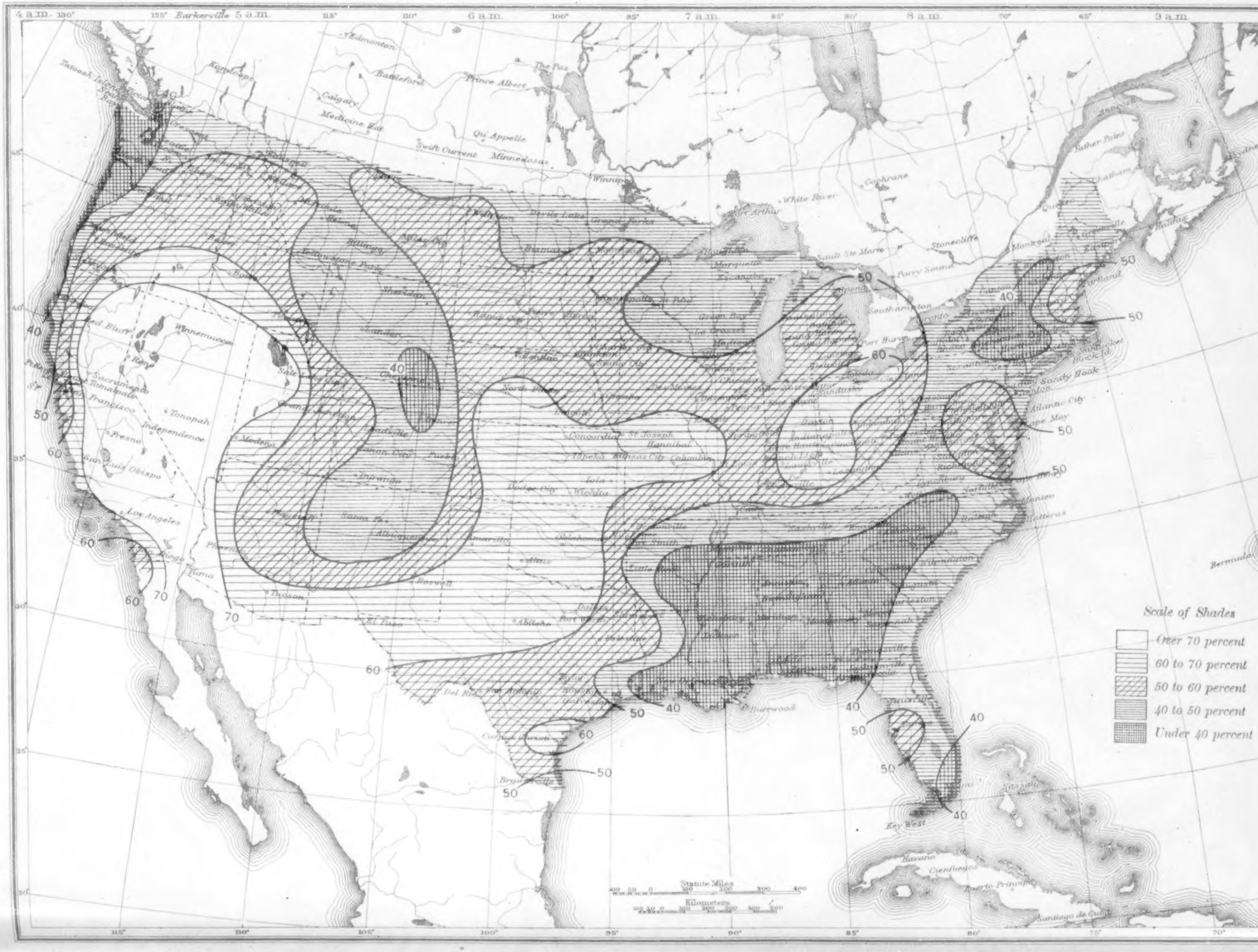


Chart V. Total Precipitation, Inches, July 1940. (Inset) Departure of Precipitation from Normal

Chart V. Total Precipitation, Inches, July 1940. (Inset) Departure of Precipitation from Normal

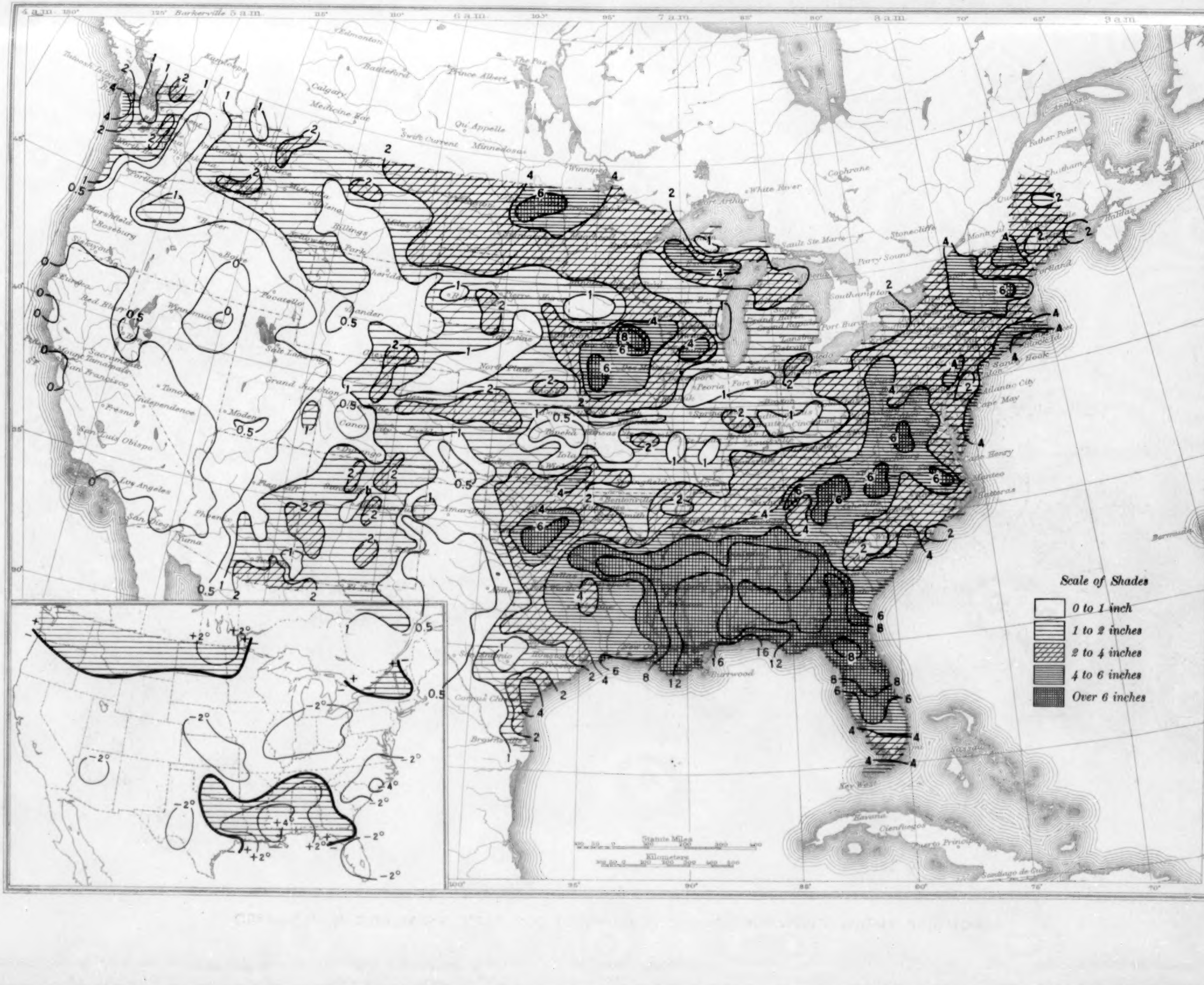
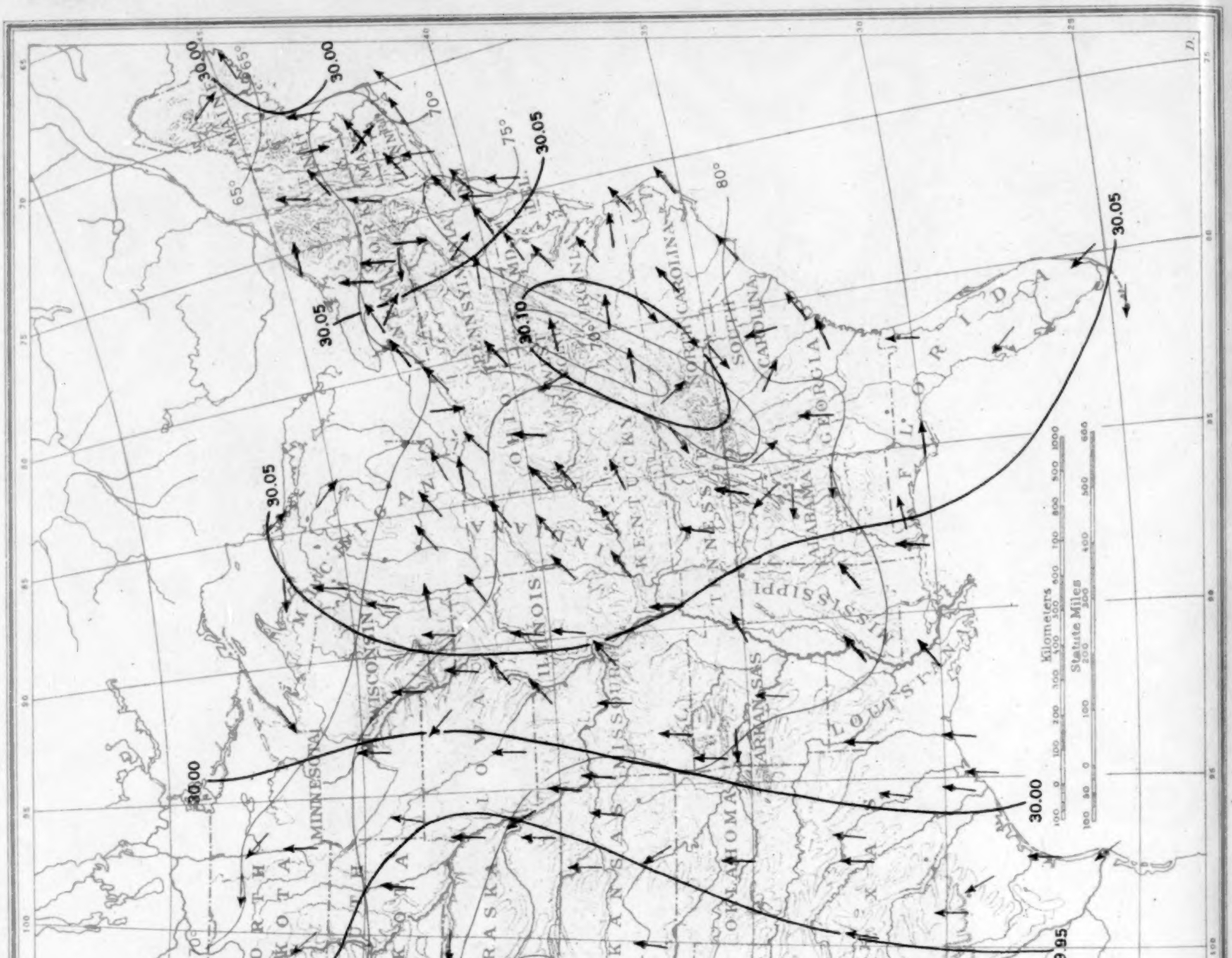


Chart VI. Isobars at Sea Level and Isotherms at Surface; Prevailing Winds, July 1940



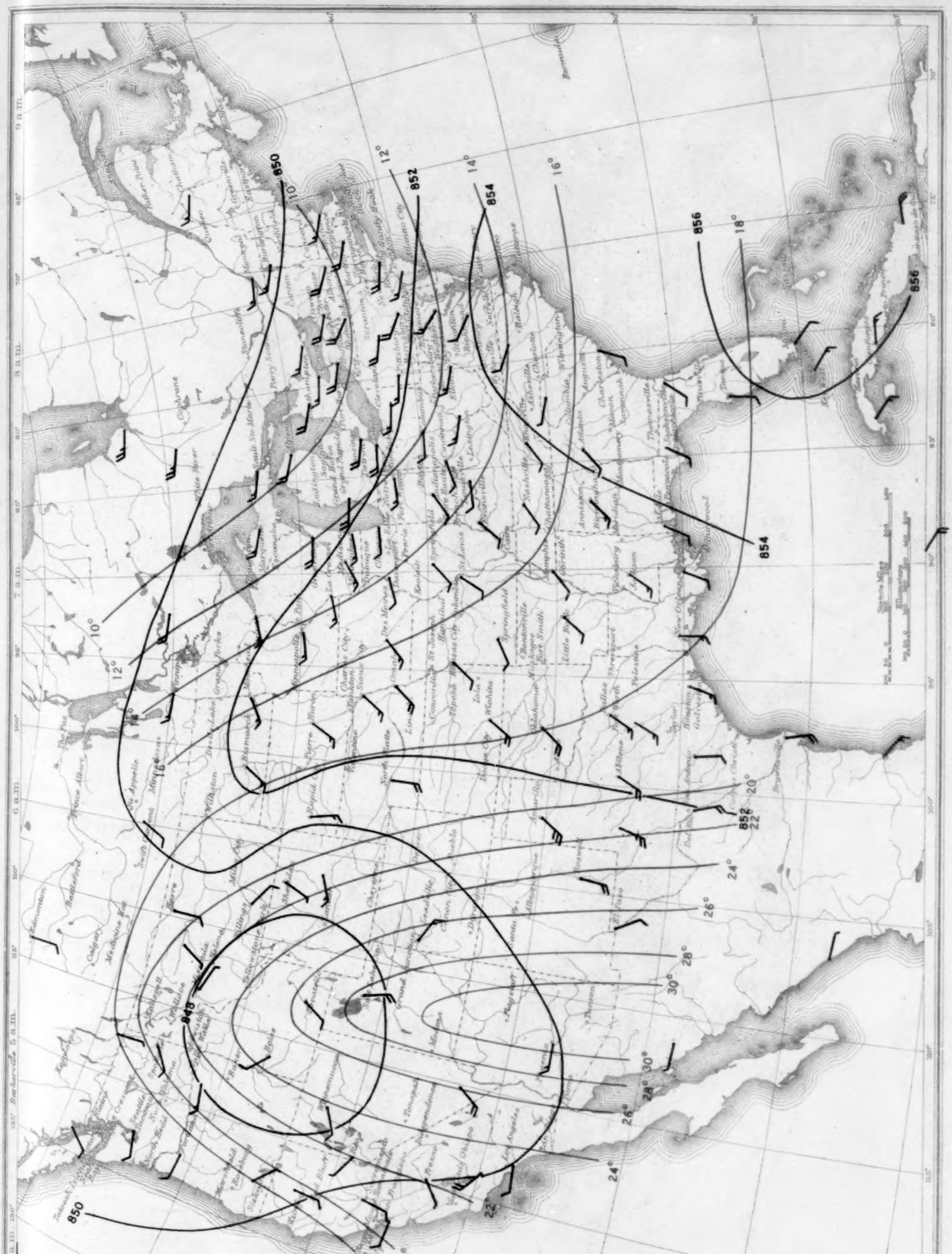


Chart VIII. Isobars (mb) for 1,524 Meters (5,000 ft.) and Isotherms (°C.) and Resultant Winds for 1,500 Meters (m. s. l.) July 1940

Chart IX. Isobars (mb) Isotherms (°C.) and Resultant Winds for 3,000 Meters (m. s. l.) July 1940

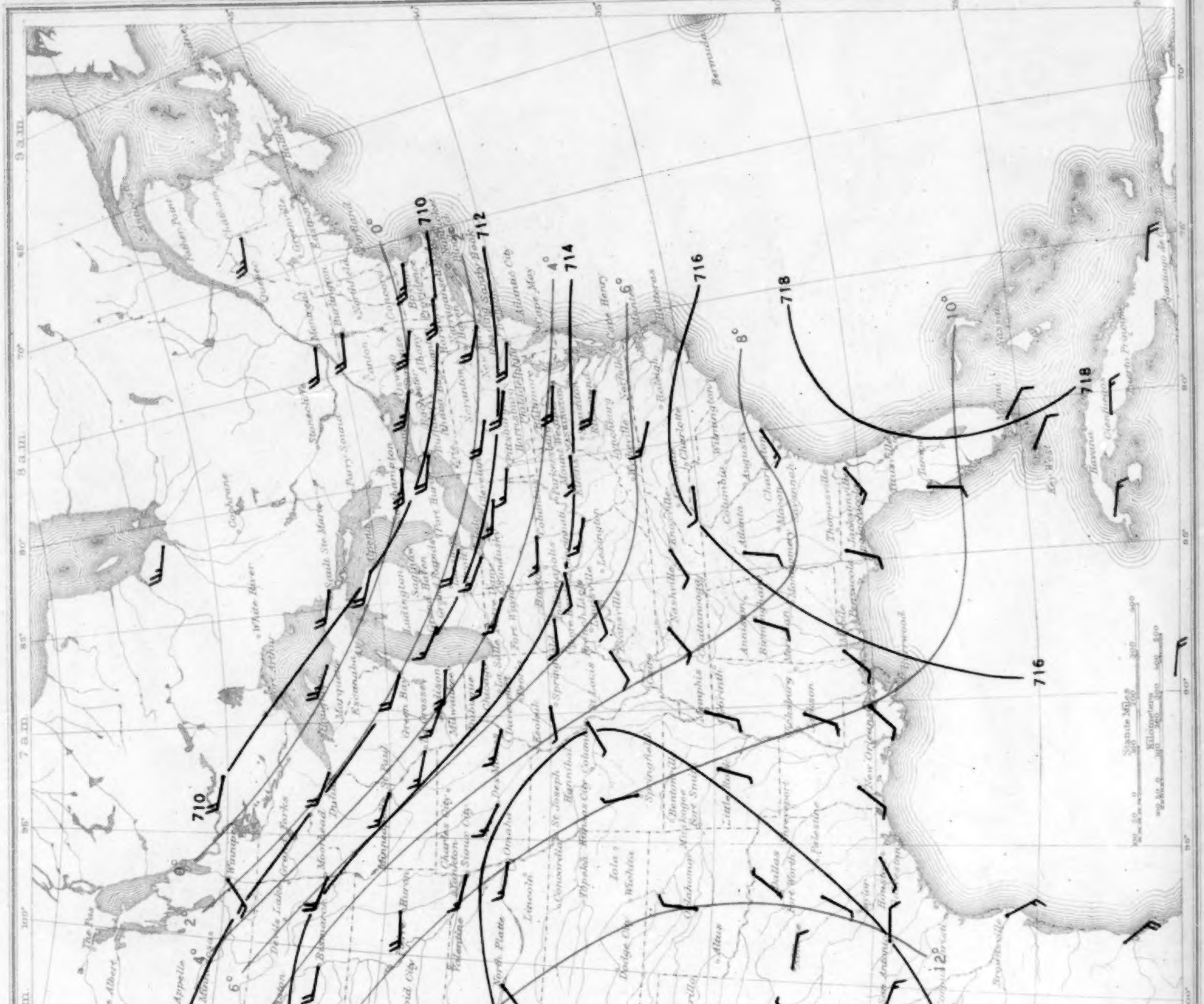


Chart X. Isobars (mb) Isotherms (°C.) and Resultant Winds for 5,000 Meters (m. s. l.) July 1940

Chart X. Isobars (mb) Isotherms (°C.) and Resultant Winds for 5,000 Meters (m. s. l.) July 1940

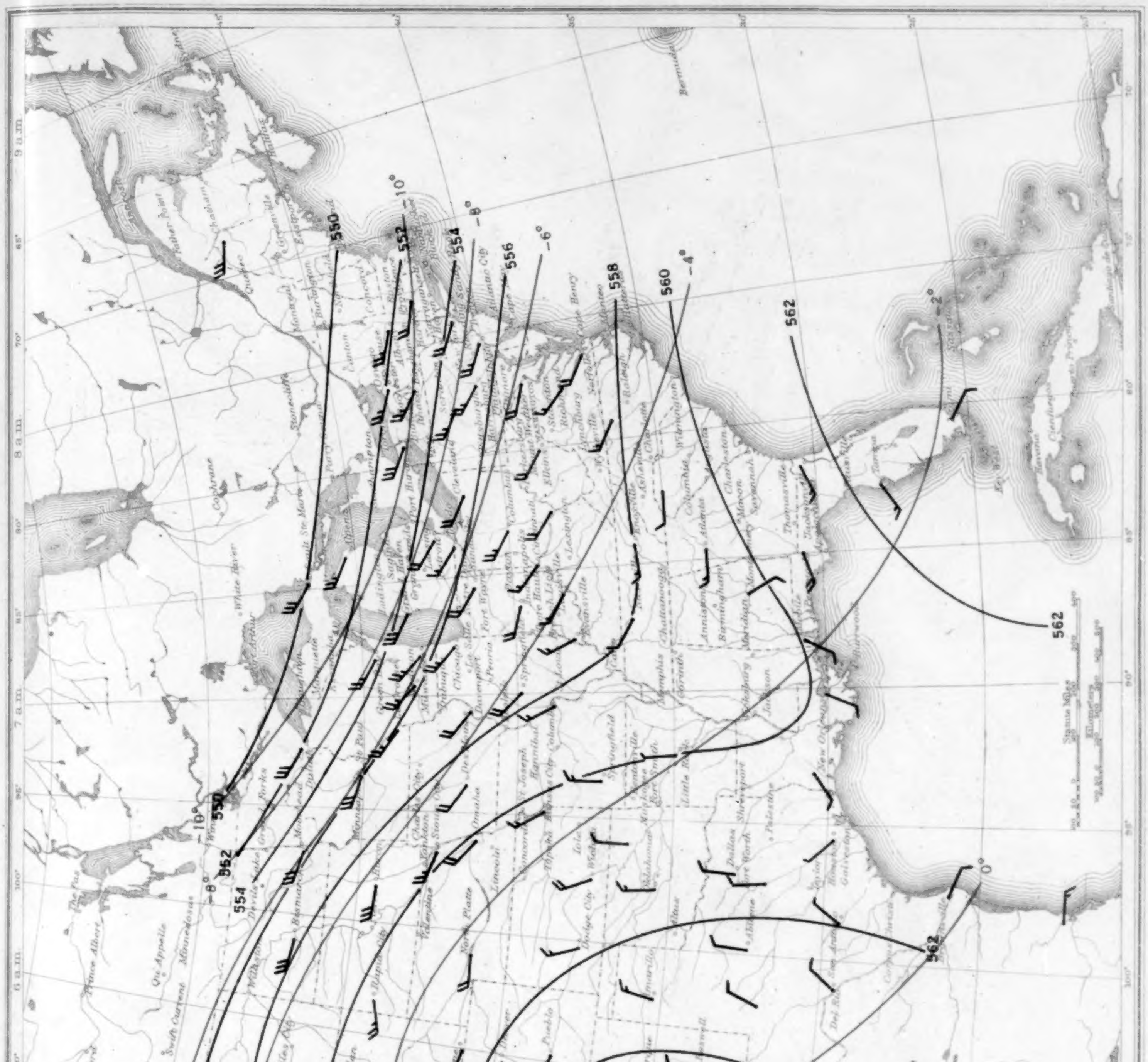


Chart XI. Isobars (mb) Isotherms (°C.) and Resultant Winds for 10,000 Meters (m. s. l.) July 1940

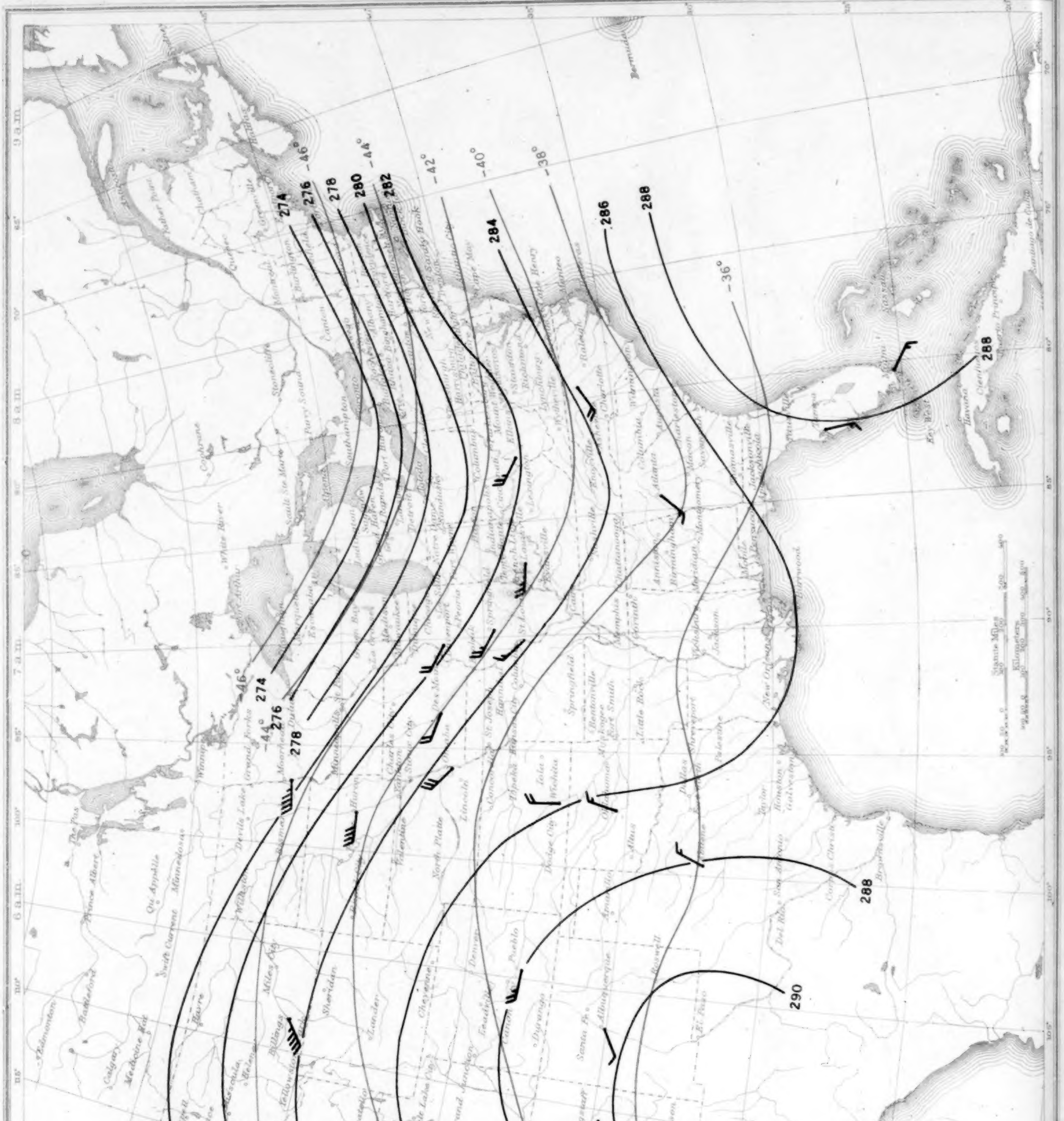


Chart XII. Mean Isentropic Chart, July 1940 (Potential Temperature 314° A.)

Chart XII. Mean Isentropic Chart, July 1940 (Potential Temperature 314° A.)

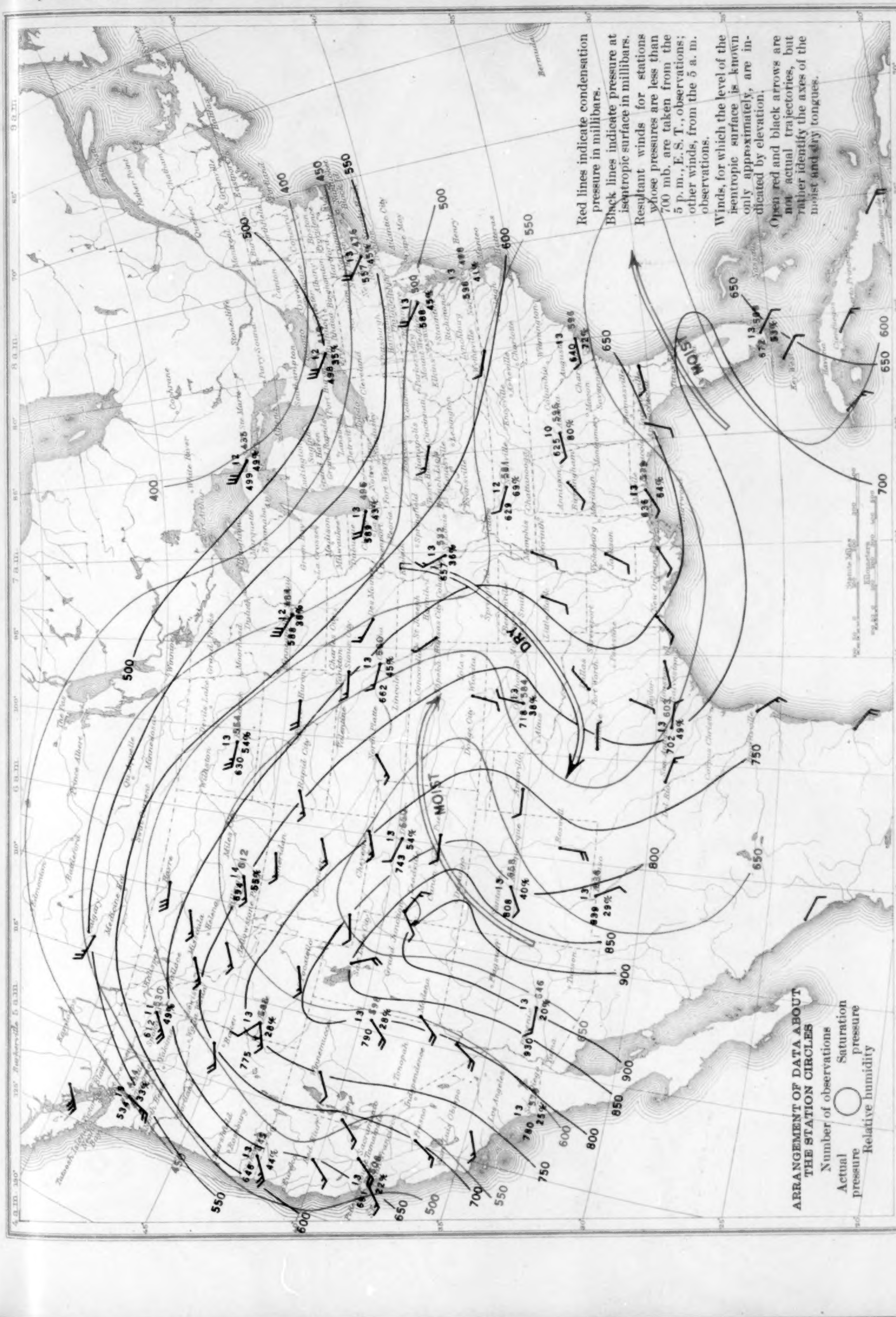


Chart XIII. Mean Tropopause Data, Altitude (km.) (m. s. l.) Temperature (°C.) July 1940

(Data from table 4)